Scilab Textbook Companion for Fundamentals Of Electrical Drive by Mohamad A. El- Sharkawi [1]

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Book Description

Title: Fundamentals Of Electrical Drive

Author: Mohamad A. El- Sharkawi

Publisher: Nelson Engineering

Edition: 1

Year: 2000

ISBN: 0534952224

Scilab numbering policy used in this document and the relation to the above book.

Exa Example (Solved example)

Eqn Equation (Particular equation of the above book)

AP Appendix to Example(Scilab Code that is an Appednix to a particular Example of the above book)

For example, Exa 3.51 means solved example 3.51 of this book. Sec 2.3 means a scilab code whose theory is explained in Section 2.3 of the book.

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Chapter 2

Introduction to solid state Devices

Scilab code Exa 2.1 calculate base current in linear and saturation region

```
//Book Name: Fundamentals of electrical drives by
   Mohamad A. El- Sharkawi
//chapter 2
//example 2.1
//edition 1
//publisher and place:Nelson Engineering
clc;
clear;
Ic=10;//collector current in ampere
beta1=200; // current gain in the linear region
beta2=10; //current gain in the saturation region
Ib1=(Ic/beta1); //base current in the linear region
   in ampere
Ib2=(Ic/beta2); //base current in the saturation
   region in ampere
disp(Ib1,'The base current in the linear region in
   ampere is')
```

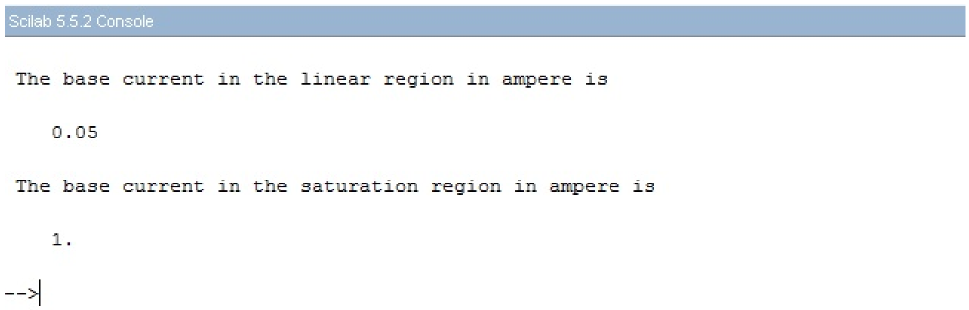


Figure 2.1: calculate base current in linear and saturation region

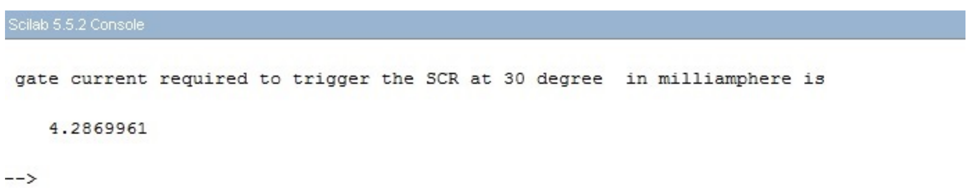


Figure 2.2: calculate the approximate value of dc gate current

```
disp(Ib2,'The base current in the saturation region
    in ampere is')
```

Scilab code Exa 2.2 calculate the approximate value of dc gate current

```
//Book name: Fundamentals of electrical drives by
    Mohamad A. El- Sharkawi
//chapter2
//example 2.2
```

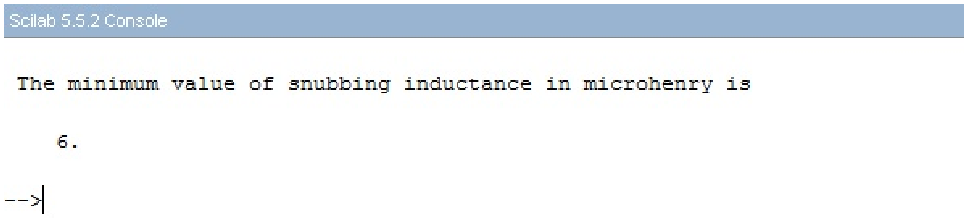


Figure 2.3: To calculate the minimum value of snubbing inductance

```
clc;
clear;
sv=(2^(1/2))*120*sind(30);//rms value of voltage
    source
K=0.2; // constant whose value dependent ondevice
    characteristics
bv=200; //base voltage in volts
ig=((log(sv/bv))/(-K)); //gate current in mA
disp(ig,'gate current required to trigger the SCR at
     30 degree  in milliamphere is')
```

Scilab code Exa 2.3 To calculate the minimum value of snubbing inductance

```
// Book Name: Fundametals of electrical drives by
    Mohamad A. El- Sharkawi
//chapter 2
//example 2.3
//edition 1
//publisher and place:Nelson Engineering
clc;
clear;
VBO=300; //base voltage in volts
```

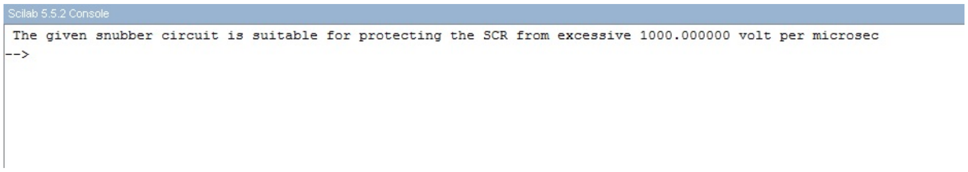


Figure 2.4: Design a snubbing circuit to protect a SCR from excessive change in volume by time

```
de=100; //maximum di/dt of SCR in A/microsec
Vs=120; //source voltage rms value in volts
L=(VBO/(0.5*de));
disp(L,'The minimum value of snubbing inductance in
    microhenry is')
```

Scilab code Exa 2.4 Design a snubbing circuit to protect a SCR from excessive chan

```
//Book name: Fundamentals of electrical drives by
    Mohamad A. El- Sharkawi
//chapter2
//example 2.4
//edition 1
//publisher and place:Nelson Engineering
clc;
clear;
Ls=8;//snubbing inductor in microhenry
VBO=4000;//base voltage in volts
di=200;//rate of change of current (di/dt) in
    amperes per microsec
dv=1500;//rate of change of voltage (dv/dt) in volt
    per microsce
Cs=10;//snubbing capacitance in microfarad
Rs=sqrt(VBO/(0.5*di*Cs));//snubbing resistance in
    ohms
```

```
dVscr=((Rs*VBO)/Ls);///rate of change of SCR voltage
    with respect to time
mprintf("The given snubber circuit is suitable for
   protecting the SCR from excessive %f volt per
   microsec",dVscr)
```

Chapter 3

Introduction to solid state switching circuits

Scilab code Exa 3.1 `calculate the average current`

```
o//Book name: Fundamentals of electrical drives by Mohamad A. El- Sharkawi
//chapter 3
//example 3.1
//edition 1
//publisher and place:Nelson Engineering
clc;
```

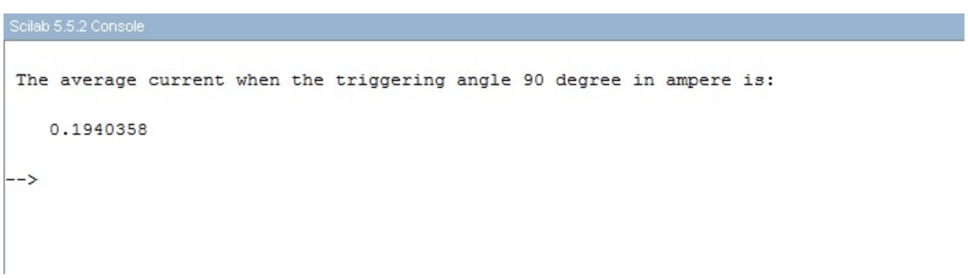
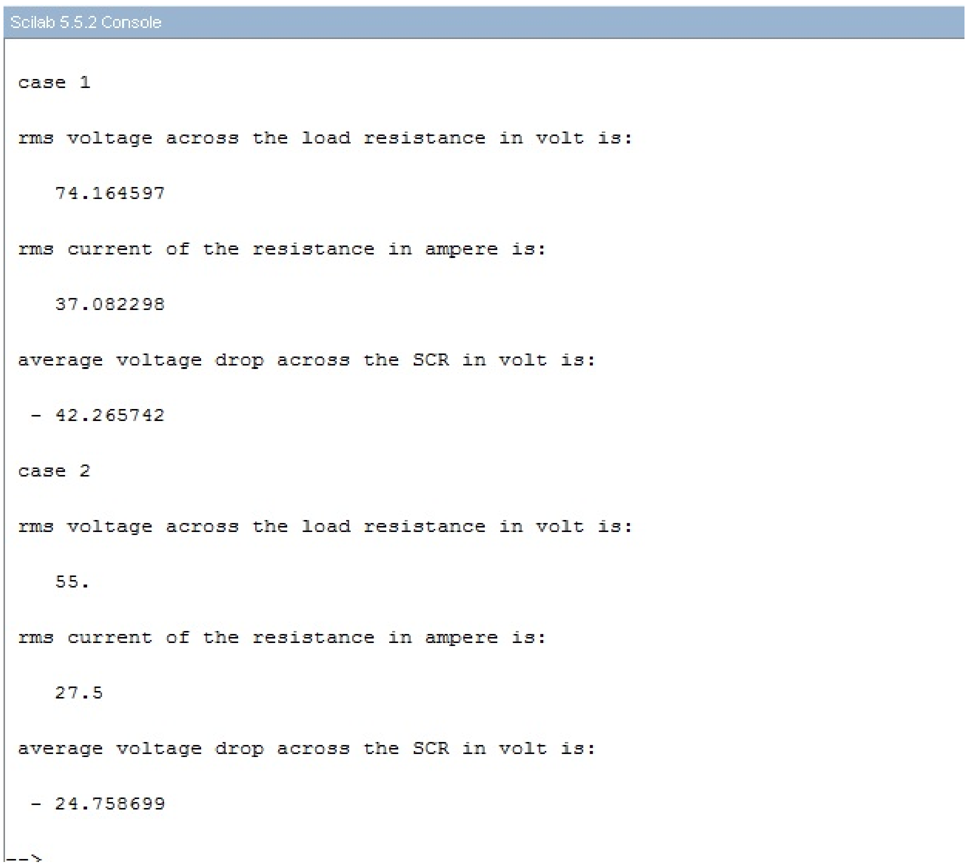


Figure 3.1: calculate the average current

```
clear;
Vrms=110;                    //source voltage of the circuit in volts
alpha=90;                    //triggering angle in degree
Vm=Vrms*(2)^(1/2);           //maximum voltage in volts
Vave=(Vm/(2*%pi))*(1+cosd(alpha));
R=(0.2*(Vave)^(2))+5;        //load resistance in ohm
Iave=Vave/R;                 //average current of the load
disp(Iave,'The average current when the triggering angle 90 degree in ampere is:')
```

Scilab code Exa 3.2 calculate rms voltage rms current average voltage drop

```
//Book name: Fundamentals of electrical drives by Mohamad A. El- Sharkawi
//chapter3
//example 3.2
//edition 1
//publisher and place:Nelson Engineering
clc;
clear;
Vsrms=110;                   //source voltage of the circuit in volts
Vm=Vsrms*(2)^(1/2);          //maximum voltage in volts
R=2;                         //resistance in ohm
alpha1=45;                   //triggering angle in degree
alpha2=90;                   //triggering angle in degree
//when a1=45
disp('case 1')
Vrms=(Vsrms/(2)^(1/2))*(1-(alpha1*(%pi/180)/%pi)+(sind(2*alpha1)/(2*%pi)))^(1/2);
disp(Vrms,'rms voltage across the load resistance in
```



```
Scilab 5.5.2 Console

case 1

rms voltage across the load resistance in volt is:

   74.164597

rms current of the resistance in ampere is:

   37.082298

average voltage drop across the SCR in volt is:

 - 42.265742

case 2

rms voltage across the load resistance in volt is:

   55.

rms current of the resistance in ampere is:

   27.5

average voltage drop across the SCR in volt is:

 - 24.758699

-->
```

Figure 3.2: calculate rms voltage rms current average voltage drop

```
    volt is:')
Irms=Vrms/R ;
disp(Irms,'rms current of the resistance in ampere
   is:')
Vscr=-(Vm/(2*%pi))*(1+cosd(alpha1));
disp(Vscr,'average voltage drop across the SCR in
   volt is:')
//when a2=90
disp('case 2')
Vrms1=(Vsrms/(2)^(1/2))*(1-(alpha2*(%pi/180)/%pi)+(
   sind(2*alpha2)/(2*%pi)))^(1/2);
disp(Vrms1,'rms voltage across the load resistance
   in volt is:')
Irms1=Vrms1/R ;
disp(Irms1,'rms current of the resistance in ampere
   is:')
Vscr1=-(Vm/(2*%pi))*(1+cosd(alpha2));
disp(Vscr1,'average voltage drop across the SCR in
   volt is:')
```

Scilab code Exa 3.3 compute power dissipated in the load resistance

```
//Book name: Fundamentals of electrical drives by
   Mohamad A. El- Sharkawi
//chapter 3
//example 3.3
//edition 1
//publisher and place:Nelson Engineering
clc;
clear;
Vrms=110;                          //The voltage on
   the ac side in volts
R=10;                              //Resistance value
```

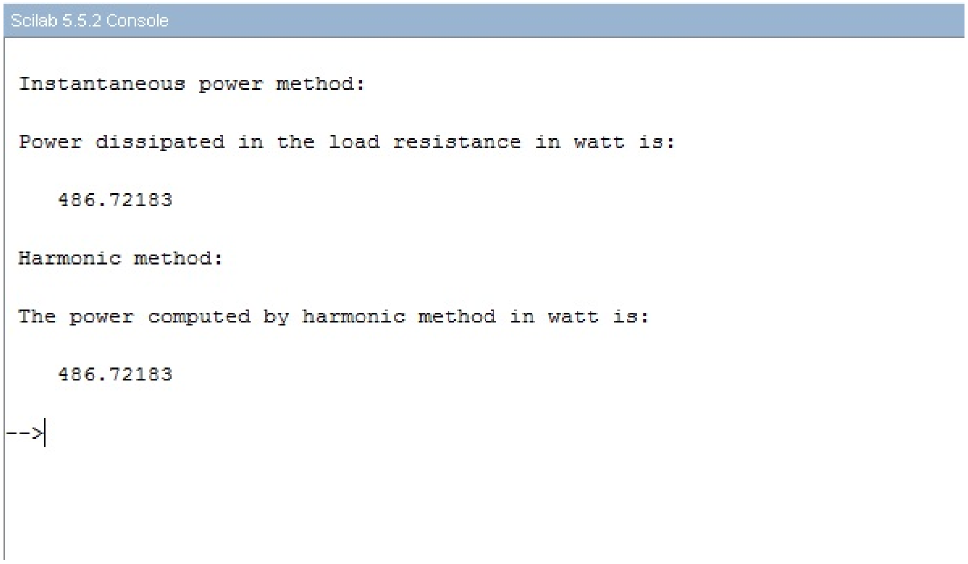


Figure 3.3: compute power dissipated in the load resistance

```
    of the resistive load in ohm
alpha=60;                          //triggering angle of the converter in degree
Vm=110*(2)^(1/2);                  //maximum voltage in volts
disp('Instantaneous power method:')
P=((Vm)^(2)/(8*%pi*R))*(2*(%pi-alpha*(%pi/180))+sind(2*alpha));
disp(P,'Power dissipated in the load resistance in watt is:')
disp('Harmonic method:')
a1=(Vm/(2*%pi*R))*(cosd(2*alpha)-1);
b1=(Vm/(4*%pi*R))*(sind(2*alpha)+(2*(%pi-alpha*(%pi/180))));
c1=(a1^(2)+b1^(2))^(1/2);
pie1=atand(a1/b1);
P1=(Vm*c1*cosd(pie1))/2;
disp(P1,'The power computed by harmonic method in watt is:')
```

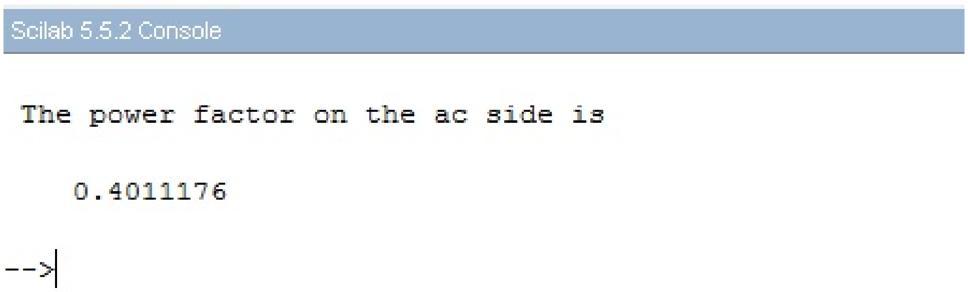


Figure 3.4: compute power factor at the ac side

Scilab code Exa 3.4 `compute power factor at the ac side`

```
//Book name: Fundamentals of electrical drives by Mohamad A. El- Sharkawi
//chapter 3
//example 3.4
//edition 1
//publisher and place:Nelson Engineering
clc;
clear;
Vrms=110;                               //The voltage on the ac side in volts
R=10;                                   //Resistance value of the resistive load in ohm
alpha=60;                               //triggering angle of the converter in degree
Vm=110*(2)^(1/2);                       //maximum voltage
```

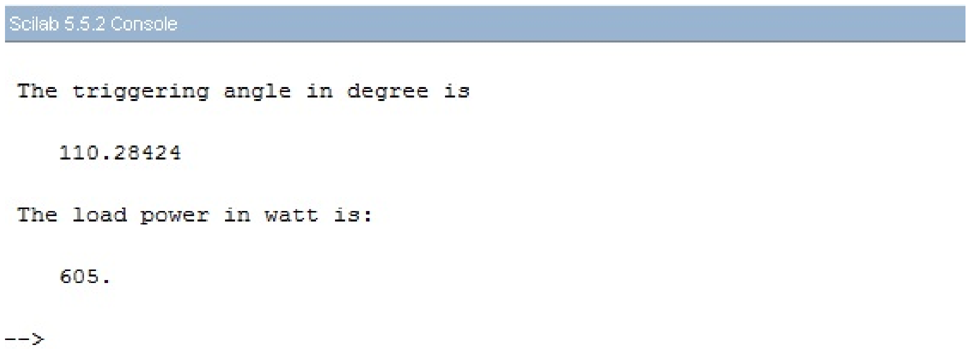


Figure 3.5: calculate the triggering angle and the load power

```
    in volts
a1=(Vm/(2*%pi*R))*(cosd(2*alpha)-1);
b1=(Vm/(4*%pi*R))*(sind(2*alpha)+(2*(%pi-alpha*(%pi
    /180))));
c1=(a1^(2)+b1^(2))^(1/2);
pie1=atand(a1/b1);
pie1=abs(pie1);
I1rms=c1/sqrt(2);
Irms=(Vrms/R)*sqrt(1-((alpha/%pi)*(%pi/180))+(sin(2*
    alpha)/(2*%pi)));
pf=(I1rms/Irms)*cos(pie1);
disp(pf,'The power factor on the ac side is')
//The answers vary due to round off error
```

Scilab code Exa 3.5 calculate the triggering angle and the load power

```
//Book name: Fundamentals of electrical drives by
    Mohamad A. El- Sharkawi
//chapter 3
//example 3.5
//edition 1
//publishing place:Thomson Learning
clc;
clear;
Vsrms=110;//The voltage on the ac side in volts
R=5;//Resistance value of the resistive load in ohm
Vrms=55;//voltage across the load
//iteration method
xold=1;//assumed value
x=(180/%pi)*(2.25+(sind(2*xold)/2));
err=100;//assumed value
while(err>0.0001)
    xnew=(180/%pi)*(2.25+(sind(2*x)/2));
    x=xnew;
    err=abs(xnew-xold);
    xold=x;
  end
disp(x,'The triggering angle in degree is')
P=(Vrms)^2/R;
disp(P,'The load power in watt is:')
//The answer given in the book is wrong
```

Scilab code Exa 3.6 calculate conduction period

```
//Book name: Fundamentals of electrical drives by
    Mohamad A. El- Sharkawi
//chapter 3
//example 3.6
//edition 1
```

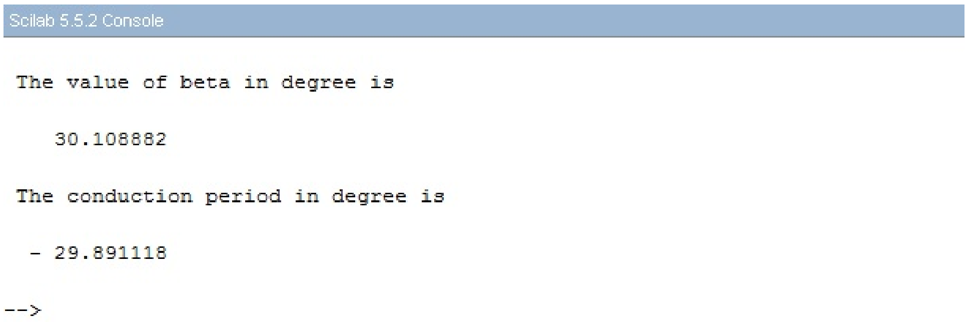


Figure 3.6: calculate conduction period

```
//publisher and place:Nelson Engineering
clc;
clear;
R=10;//resistance of the load in ohm
L=0.03;//inductance in H
Vrms=100;//source voltage in volt
f=60;//frequency in Hz
alpha=60;//triggering angle in degree
omega=2*%pi*f;
tau=L/R;
Q=atand((omega*L)/R);
//iteration method
xold=1;//assumed value
x=Q+asind(sind(Q-alpha)*exp((-1)*(((xold-alpha)*(%pi
    /180))/(omega*tau))));
err=10;//assumed value
while(err>0.01)
    xnew=Q+asind(sind(Q-alpha)*exp((-1)*((x-alpha)*(
        %pi/180)/(omega*tau))));
    x=xnew;
    err=abs(xnew-xold);
    xold=x;
  end
```

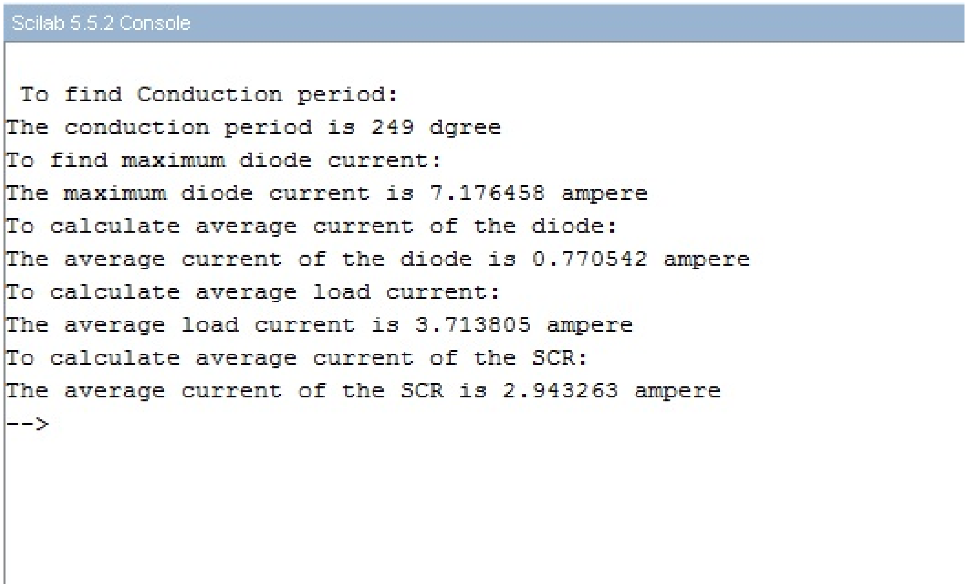


Figure 3.7: calculate conduction period maximum and average diode current and average current of SCR

```
disp(x,'The value of beta in degree is')
r=x-alpha;
disp(r,'The conduction period in degree is ')
//The answer given in the book is wrong.While using
   the book answer both LHS and RHS are not equal.
```

Scilab code Exa 3.7 `calculate conduction period maximum and average diode current`

```
//Book name: Fundamentals of electrical drives by
   Mohamad A. El- Sharkawi
//chapter 3
//example 3.7
//edition 1
//publisher and place:Nelson Engineering
```

```
clc;
clear;
Vs=110;//source voltage in volts
L=20e-3;//inductance of the circuit in henry
R=10;//resistance of the circuit in ohm
a=60;//trigerring angle in degree
r1=a*(%pi/180);
Vm=Vs*2^(1/2);
T=L/R;//Time constant of the circuit in sec
w=2*%pi*a;//rotational speed in rad/sec
mprintf("\n To find Conduction period:")
b=(%pi-(w*T*log(0.05)))*(180/%pi);
gama=b-a;//conduction period in degree
mprintf("\nThe conduction period is %d dgree",gama)
mprintf("\nTo find maximum diode current:")
Z=sqrt(R^2+(w*L)^2);
wtau=(w*L)/R;
Q=atand(wtau);
l=exp((-1)*((%pi-(a*(%pi/180)))/wtau));
c=(%pi-(a*(%pi/180)));
id=(Vm/Z)*(sind(Q)+((sind(Q-a))*l));
mprintf("\nThe maximum diode current is %f ampere",
   id)
mprintf("\nTo calculate average current of the diode
   :")
Idave=(id/(2*%pi))*(-wtau)*(exp((-1)*(b*(%pi/180)-
   %pi))-1);
mprintf("\nThe average current of the diode is %f
   ampere",Idave)
mprintf("\nTo calculate average load current:")
Vave=(Vm/(2*%pi))*(1+(cosd(a)));
Iave=Vave/R;
mprintf("\nThe average load current is %f ampere",
   Iave)
mprintf("\nTo calculate average current of the SCR:"
   )
ISCR=Iave-Idave;
mprintf("\nThe average current of the SCR is %f
```

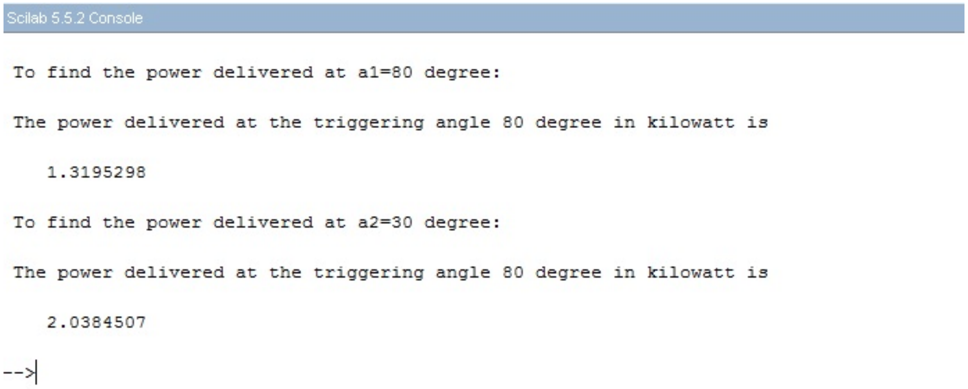


Figure 3.8: calculate power delivered to the load when the triggering angle is 80 and 30 dgree

```
    ampere",ISCR)
```

Scilab code Exa 3.8 `calculate power delivered to the load when the triggering angl`

```
//Book name: Fundamentals of electrical drives by
    Mohamad A. El- Sharkawi
//chapter 3
//example 3.8
//edition 1
//publisher and place:Nelson Engineering
clc;
clear;
Vab=208;//source voltage in volts
Vs=Vab/3^(1/2);//rms voltage in volts
Vm=Vs*2^(1/2);//maximum peak voltage in volts
R=10;//resistance of the circuit in ohm
```

```
a1=80;//triggering angle 1 in degree
a2=30;//triggering angle 2 in degree
if a1<60 then
    disp(a1,'The current is discontinous')
else if (a2>60)
        disp(a2,'The current is discontinous')
end
disp('To find the power delivered at a1=80 degree:')
B1=180;
p=(((3*Vm^(2))/(8*%pi*10))*(2*(B1-a1)*(%pi/180)+sind(2*a1)-sind(2*B1)));//power delivered when triggering angle a1=180 degree
P=p*10^-3;//power interms of kilowatt
disp(P,'The power delivered at the triggering angle 80 degree in kilowatt is')
disp('To find the power delivered at a2=30 degree:')
B2=120+a2;
p1=(((3*Vm^(2))/(8*%pi*10))*(2*(B2-a2)*(%pi/180)+sind(2*a2)-sind(2*B2)));//power delivered when triggering angle a2=30 degree
P1=p1*10^-3;//power interms of kilowatt
disp(P1,'The power delivered at the triggering angle 80 degree in kilowatt is')
```

Scilab code Exa 3.9 calculate maximum average voltage and triggering angle and loa

```
//Book name: Fundamentals of electrical drives by Mohamad A. El- Sharkawi
//chapter 3
//example 3.9
//edition 1
//publisher and place:Nelson Engineering
clc;
```

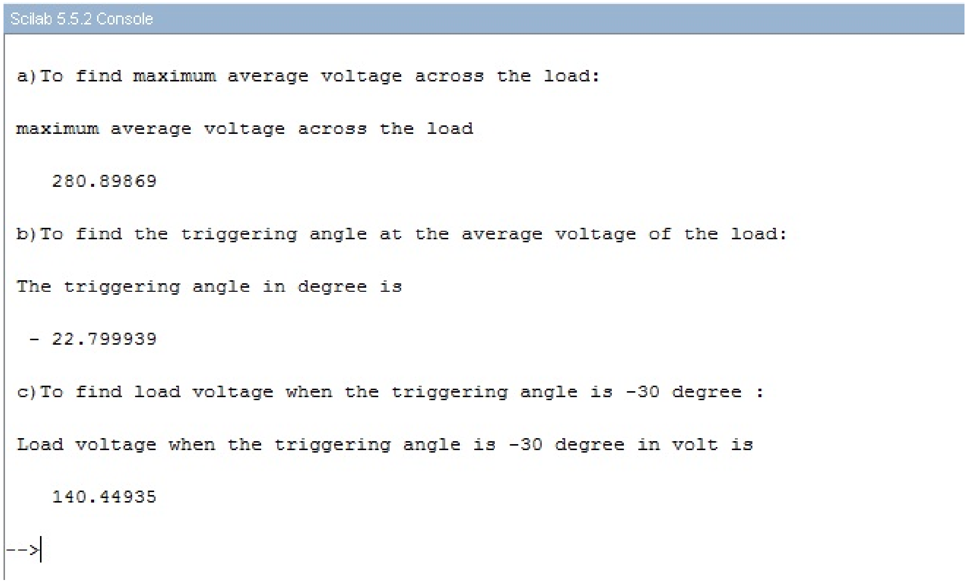


Figure 3.9: calculate maximum average voltage and triggering angle and load voltage

```
clear;
Vab=208;//source voltage in volts
Vs=Vab/3^(1/2);//rms voltage in volts
Vm=Vs*2^(1/2);//maximum peak voltage in volts
disp('a)To find maximum average voltage across the load:')
Vavemax=(3*3^(1/2)*Vm)/%pi;
disp(Vavemax,'maximum average voltage across the load')
disp('b)To find the triggering angle at the average voltage of the load:')
xold=1;//assumed value
c=30;//constant value
x=asind((%pi/(3*sqrt(3)))-(cosd(xold+c)));
err=100;//assumed value
while(err>0.0001)
    xnew=asind((%pi/(3*sqrt(3)))-(cosd(x+c)));
    x=xnew;
```

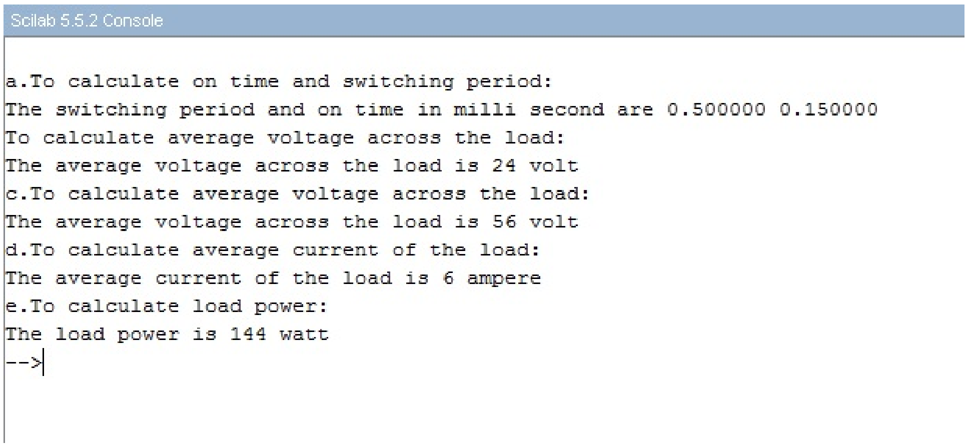


Figure 3.10: calculate on time and switching period average voltage across load and diode average current and load power

```
    err=abs(xnew-xold);
    xold=x;
   end
disp(x,'The triggering angle in degree is')
disp('c)To find load voltage when the triggering
   angle is −30 degree :')
Vave=(3*3^(1/2)*Vm)/(2*%pi);
disp(Vave,'Load voltage when the triggering angle is
    −30 degree in volt is')
//The part (b) answer given in the book is wrong
```

Scilab code Exa 3.10 calculate on time and switching period average voltage across

```
//Book name: Fundamentals of electrical drives by
   Mohamad A. El− Sharkawi
//chapter 3
//example 3.10
//edition 1
```

```
//publisher and place:Nelson Engineering
clc;
clear;
f=2;                                    //switching frequency of chopper in kilohertz
Vs=80;                                  //source voltage in volts
k=.3;                                   //duty ratio
R=4;                                    //load resistance in ohm
mprintf("\na.To calculate on time and switching period:")
t=1/f;                              //switching period in milli sec
ton=k*t;                            //on time in milli sec
mprintf("\nThe switching period and on time in milli second are %f %f",t,ton)
mprintf("\nTo calculate average voltage across the load:")
Vave=k*Vs;
mprintf("\nThe average voltage across the load is %d volt",Vave)
mprintf("\nc.To calculate average voltage across the load:")
Vdave=(1-k)*Vs;               //obtained by integrating Vs with respect to ton and t
mprintf("\nThe average voltage across the load is %d volt",Vdave)
mprintf("\nd.To calculate average current of the load:")
Iave=Vave/R;
mprintf("\nThe average current of the load is %d ampere",Iave)
mprintf("\ne.To calculate load power:")
P=Vave*Iave;
mprintf("\nThe load power is %d watt",P)
```

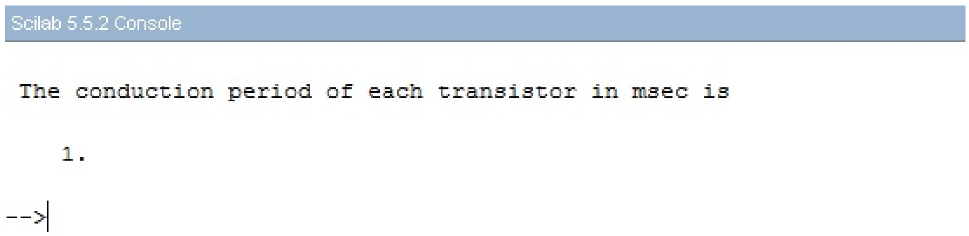


Figure 3.11: calculation of conduction period of each transistor

Scilab code Exa 3.12 calculation of conduction period of each transistor

```
//Book name: Fundamentals of electrical drives by Mohamad A. El- Sharkawi
//chapter 3
//example 3.12
//edition 1
//publisher and place:Nelson Engineering
clc;
clear;
f=500;                              //frequency at the load side in Hz
t=1/f;                              //time for one cycle in sec
tseg=t/6;                           //time of the switching segment in sec
tcon=3*tseg;                        //conduction period of each transistor in sec
tcon1=tcon*10^3;                    //conduction period of each transistor in msec
disp(tcon1,'The conduction period of each transistor
```

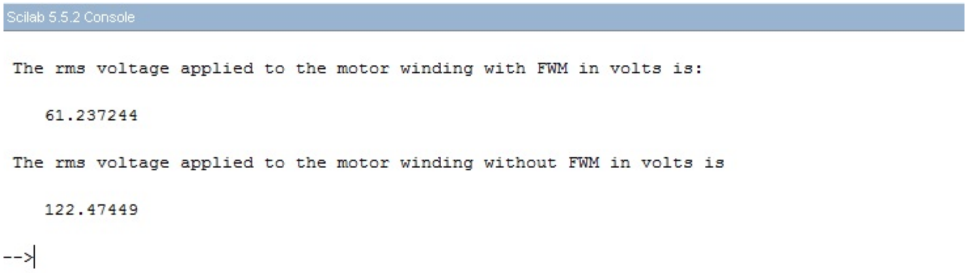


Figure 3.12: calculate rms voltage applied to the motor

```
in msec is')
```

Scilab code Exa 3.13 `calculate rms voltage applied to the motor`

```
//Book name: Fundamentals of electrical drives by Mohamad A. El- Sharkawi
//chapter 3
//example 3.13
//edition 1
//publisher and place:Nelson Engineering
clc;
clear;
d=.25;                          //duty ratio
Vdc=150;                        //source voltage in volts
Vab=((2*d)/3)^(1/2)*Vdc;        //rms voltage applied to the motor winding with FWM
disp(Vab,'The rms voltage applied to the motor winding with FWM in volts is:')
Vab1=(Vab/d^(1/2));             //rms voltage applied to the motor winding without FWM
```

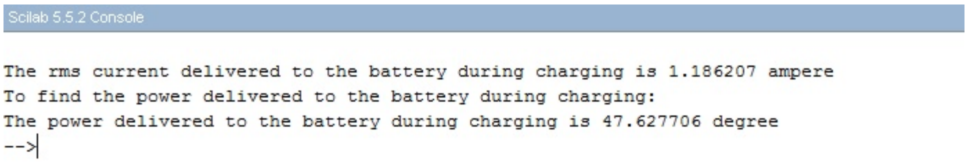


Figure 3.13: calculate the rms current and the power delivered to battery during charging

```
disp(Vab1,'The rms voltage applied to the motor winding without FWM in volts is')
```

Scilab code Exa 3.14 `calculate the rms current and the power delivered to battery`

```
//Book name: Fundamentals of electrical drives by Mohamad A. El- Sharkawi
//chapter 3
//example 3.14
//edition 1
//publisher and place:Nelson Engineering
clc;
clear;
Vs=110;                                                      //source voltage in volts
Vdc=150;                                                     //DC voltage in volts
Vm=Vs*2^(1/2);                                               //maximum voltage in volts
a=90;
```

```
//triggering angle in degree
R=1;                                               //resistance in ohm
theta=asind(Vdc/Vm);
theta1=75;                                         //approximated value of theta in degree
B=180-theta1;                                      //The value of bete
gama=B-a;                                          //conduction period in degree
VRrms=((Vdc^(2)*gama/180)+((Vm^(2)/(2*%pi))*(gama*(%pi/180)-(sind(2*B)-sind(2*a))/2)-((2*Vdc*Vm)/%pi)*(cosd(a)-cosd(B))))^(1/2);
Icrms=VRrms/R;                                     //rms current
mprintf("\nThe rms current delivered to the battery during charging is %f ampere",Icrms)
mprintf("\nTo find the power delivered to the battery during charging:")
a1=((Vm/(R*%pi))*(((1-cosd(2*B))/2)-((1-cosd(2*a))/2)))-(((2*Vdc)/(R*%pi))*(sind(B)-sind(a)));
b1=((Vm/(R*%pi))*(gama*(%pi/180)+((sind(2*a)-sind(2*B))/2)))-(((2*Vdc)/(R*%pi))*(cosd(a)-cosd(B)));
pie1=atand(a1/b1);
I1crms=sqrt(a1^2+b1^2)/sqrt(2);
Ps=Vs*I1crms*cosd(pie1);
Ploss=Icrms*R;
Pcharge=Ps-Ploss;
mprintf("\nThe power delivered to the battery during charging is %f degree",Pcharge)
```

Scilab code Exa 3.15 calculate the rms current and the power delivered to battery

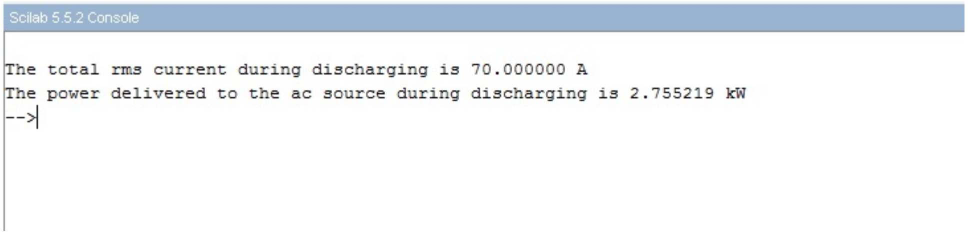


Figure 3.14: calculate the rms current and the power delivered to battery during discharging

```
//Book name: Fundamentals of electrical drives by
   Mohamad A. El- Sharkawi
//chapter 3
//example 3.15
//edition 1
//publisher and place:Nelson Engineering
clc;
clear;
Vs=110;//source voltage in volts
Vdc=150;//DC voltage in volts
Vm=Vs*2^(1/2);//maximum voltage in volts
alphamin=0;//triggering angle in degree
R=1;//resistance in ohm
Beta=180;//The value of bete
gama=Beta-alphamin;//conduction period in degree
VRrms=sqrt(Vdc^(2)+((Vs*2^(1/2))^(2)/2)-((4*Vdc*Vm)/
   %pi));
VRrms=ceil(VRrms)
Idrms=VRrms/R;
mprintf("\nThe total rms current during discharging
   is %f A",Idrms)
a1=((Vm/(R*%pi))*(((1-cosd(2*Beta))/2)-((1-cosd(2*
   alphamin))/2)))-(((2*Vdc)/(R*%pi))*(sind(Beta)-
   sind(alphamin)));
b1=((4*Vdc)/(R*%pi))-(Vm/R);
pie1=atand(a1/b1);
I1drms=sqrt((a1^2+b1^2)/2);//rms value of
```

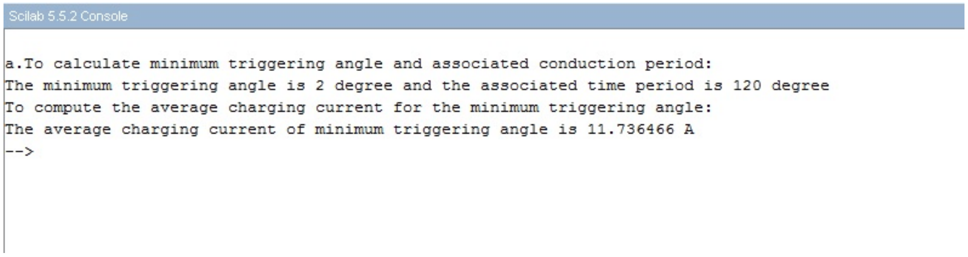


Figure 3.15: calculate minimum triggering angle and associated conduction period and average charging current

```
   fundamental component
Pac=Vs*I1drms*cosd(pie1);
Pac=Pac*10^(-3);
mprintf("\nThe power delivered to the ac source during discharging is %f kW",Pac)
```

Scilab code Exa 3.16 calculate minimum triggering angle and associated conduction

```
//Book name: Fundamentals of electrical drives by Mohamad A. El- Sharkawi
//chapter 3
//example 3.16
//edition 1
//publisher and place:Nelson Engineering
clc;
clear;
Vdc=250;
Vs=208;//line to line ac voltage
R=3;//system resistance between battery bank and source in ohm
Beta=122;
Vmax=(sqrt(2)*Vs)/sqrt(3);
```

```
mprintf("\na.To calculate minimum triggering angle and associated conduction period:")
alphamin=60-asind(Vdc/(sqrt(3)*Vmax));
alphamin=ceil(alphamin);
gama=Beta-alphamin;
mprintf("\nThe minimum triggering angle is %d degree and the associated time period is %d degree",alphamin,gama)
mprintf("\nTo compute the average charging current for the minimum triggering angle:")
VR=Vdc+(((9*Vmax)/(2*%pi))*cosd(alphamin+150));
l=((9*Vmax)/(2*%pi))*cosd(alphamin+150);
IRave=VR/R;
mprintf("\nThe average charging current of minimum triggering angle is %f A",IRave)
//The answers vary due to round off error
```

Chapter 4

Joint speed torque characterstics of electric motor and mechanical loads

Scilab code Exa 4.1 compute the power consumed by the load

```
//Book name: Fundamentals of electrical drives by
   Mohamad A. El- Sharkawi
```

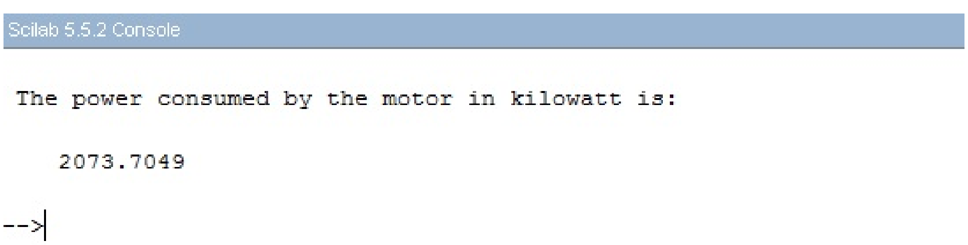


Figure 4.1: compute the power consumed by the load

```
//chapter 4
//example 4.1
//edition 1
//publisher and place:Nelson Engineering
clc;
clear;
m=5000;                                              //mass of the electric bus in kg
d=1;                                                 //diameter of the wheel in m
r=d/2;                                               //radius of the wheel in m
v=50;                                                //speed of the bus going to uphill in kg/hr
a=30;                                                //slope of the hill in degree
u=0.4;                                               //friction coefficient
g=9.8;                                               //gravitational acceleration
Fg=m*g;                                              //gravitational force in newton(N)
F=Fg*cosd(a);                                        //normal force in newton(N)
Fl=Fg*sind(a);                                       //load pulling force in newton (N)
Fr=u*F;                                              //friction force in newton(N)
Fm=Fl+Fr;                                            //total force seen by motor in newton(N)
Tm=Fm*r;                                             //Torque seen by the motor in Nm
omega=v/r;                                           //angular speed
Pm=Tm*omega;                                         //power consumed by the motor in watt
Pm=Pm*10^-3;                                         //power consumed by the motor in kilowatt
disp(Pm,'The power consumed by the motor in kilowatt
```

```
is:')
```

Chapter 5

speed torque characterstics of electric motor

Scilab code Exa 5.1 caculate rated torque starting torque and starting current

```
//Book name: Fundamentals of electrical drives by Mohamad A. El- Sharkawi
//chapter 5
//example 5.1
//edition 1
//publisher and place:Nelson Engineering
clc;
clear;
kpie=3;                        //flux in voltsec
Vt=600;                       //voltage in volts
Ra=2;                        //armature resistance in ohms
Ia=5;                       //armature current at fullload in ampere
Td=kpie*Ia;               //rated torque in Nm
disp(Td,'The rated torque in Nm is')
Tst=(Vt*kpie)/Ra;     //starting torque
```

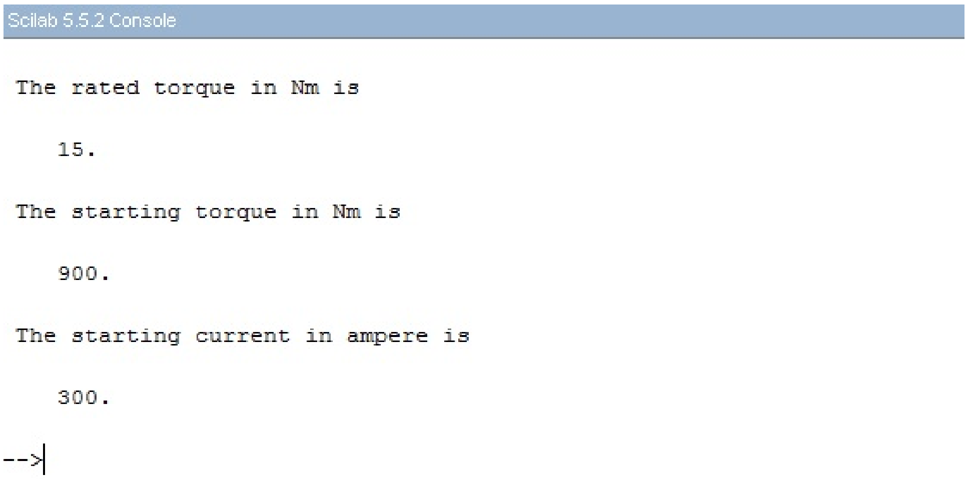


Figure 5.1: caculate rated torque starting torque and starting current

```
disp(Tst,'The starting torque in Nm is')
Ist=Vt/Ra;              //starting current
disp(Ist,'The starting current in ampere is')
```

Scilab code Exa 5.2 `compute the motor efficiency`

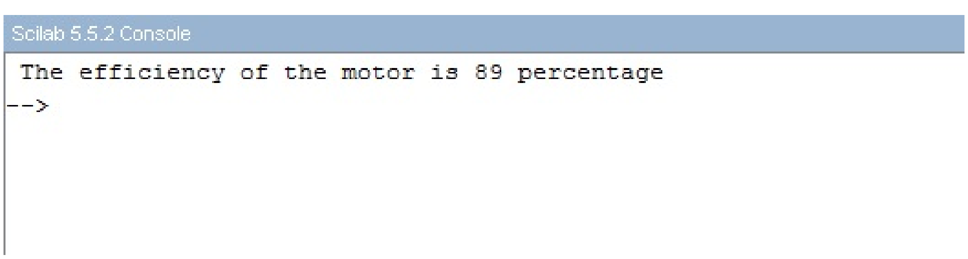
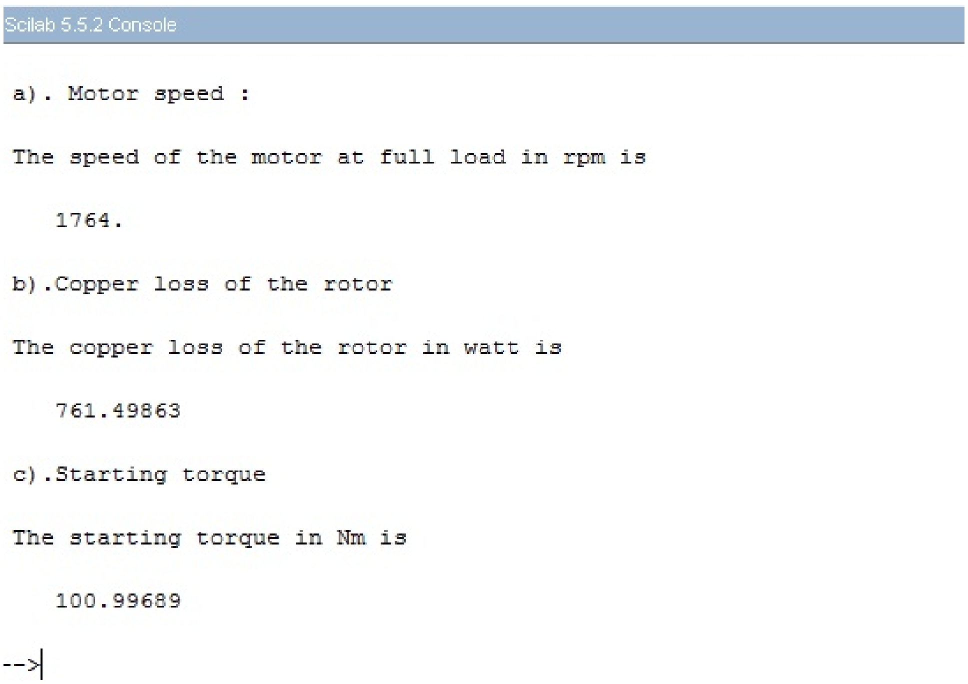


Figure 5.2: compute the motor efficiency

```
//Book name: Fundamentals of electrical drives by Mohamad A. El- Sharkawi
//chapter 5
//example 5.2
//edition 1
//publisher and place:Nelson Engineering
clc;
clear;
l=50;                                   //load in hp
f=60;                                   //frequency in hertz
n=1764;                                 //full load speed in rpm
ns=1800;                                //synchronous speed of motor in rpm
Pr=.950;                                //rotational loss in kilowatts
Pcu=1.600;                              //stator copper loss in kilowatt
Pi=1.200;                               //iron loss in kilowatt
Pout=l/1.34;                            //output power at full load is 50 hp in kilowatt
Pd=Pout+Pr;                             //power developed in kilowatt
s=(ns-n)/ns;                            //slip of the motor
Pg=Pd/(1-s);
Pin=Pg+Pcu+Pi;             //input power in kilowatt
efficiency=Pout/Pin;   //motor efficiency
efficiency=efficiency*100;//efficiency in percentage
mprintf("The efficiency of the motor is %d percentage",efficiency)
```

Scilab code Exa 5.3 calculate speed of motor copper loss starting torque of the mo



```
Scilab 5.5.2 Console

 a). Motor speed :

 The speed of the motor at full load in rpm is

    1764.

 b).Copper loss of the rotor

 The copper loss of the rotor in watt is

    761.49863

 c).Starting torque

 The starting torque in Nm is

    100.99689

-->
```

Figure 5.3: calculate speed of motor copper loss starting torque of the motor

```
//Book name: Fundamentals of electrical drives by
   Mohamad A. El- Sharkawi
//chapter 5
//example 5.3
//edition 1
//publisher and place:Nelson Engineering
clc;
clear;
l=50;//load in hp
f=60;//frequency in hertz
V=440;//voltage of the motor in volts
p=4;//Number of poles of the motor
Tmax=2.5;//maximum torque of the motor
T=1;//motor torque
smax=0.1;//maximum slip
ns=(120*f)/p;//synchronous speed in rpm
disp('a). Motor speed :')
s=(T/Tmax)*(smax/2);//the equation is obtained from
   the equation T=3V^2s/wsR2
n=ns*(1-s);//speed of the motor in rpm
disp(n,'The speed of the motor at full load in rpm
   is')
disp('b).Copper loss of the rotor')
Pd=l/1.34;//power developed  or Pout in kilowatt
Pcu2=Pd*(s/(1-s));//copper loss in kilowatt which is
    obtained from two equationsPcu2=Pg*s,Pd=Pg*(1-s)
Pcu=Pcu2*10^3;//copper loss in watt
disp(Pcu,'The copper loss of the rotor in watt is')
disp('c).Starting torque')
//At starting slip s=1
omega=(2*%pi*n)/f;
Pout=Pd*10^3;//Pout value in watts
Tst=(smax^(2)*Pout)/(s*omega);
disp(Tst,'The starting torque in Nm is')
//The answers vary due to round off error
```

Scilab code Exa 5.4 calculate the change in starting torque and resistance added t

```
//Book name: Fundamentals of electrical drives by Mohamad A. El- Sharkawi
//chapter 5
//example 5.4
//edition 1
//publisher and place:Nelson Engineering
clc;
clear;
R1=3;                                   //stator resistance in ohm
R2=2;                                   //rotor resistance referred to stator in ohm
Xeq=10;                                 //equivalent inductive reactance in ohm
l=10;                                   //voltage reduction in percentage
V=1;                                    //assumed value of V
TA=(1*V)^2;                             //starting torque at the rated voltage
TB=(0.9*V)^2;                           //starting torque after 10% voltage reduction
r=1-TB;                                 //reduction in starting torque
r=r*100;                                //reduction in starting torque in percentage
mprintf("\nThe reduction in starting torque is %f percentage",r)
Radd=sqrt(R1^(2)+Xeq^(2))-R2;
mprintf("\nThe resistance added to the rotor circuit to achieve the maximum torque is %f",Radd)
//The answer given in the book is wrong
```

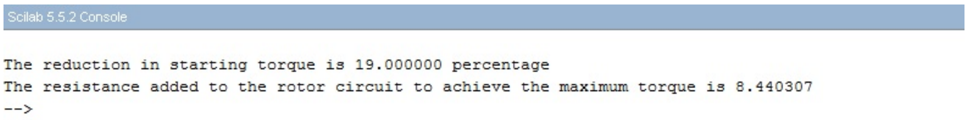


Figure 5.4: calculate the change in starting torque and resistance added to achieve maximum torque

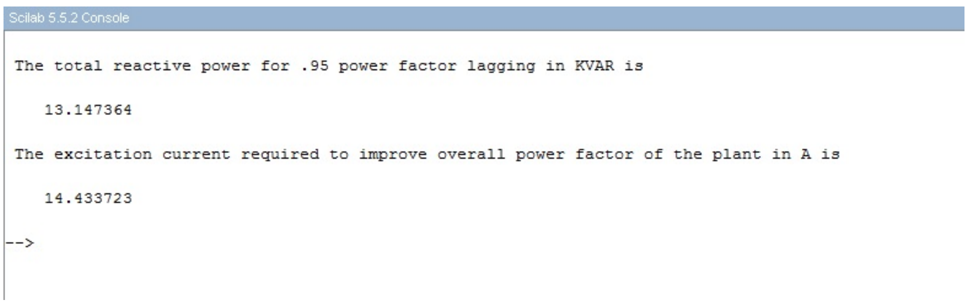


Figure 5.5: compute the excitation current to improve overall power factor

Scilab code Exa 5.5 `compute the excitation current to improve overall power factor`

```
//Book name: Fundamentals of electrical drives by
   Mohamad A. El- Sharkawi
//chapter 5
//example 5.5
//edition 1
//publisher and place:Nelson Engineering
clc;
clear;
P=40;                                    //load of an
```

```
industrial plant in Mw
pf=.85;                                  //power factor lagging
pfnew=.95                               //To improve new power factor
V=5000;                                //motor rated voltage in volts
Xs=5;                                   //synchronous reactance in ohm
c=200;                                 //constant value given
Vt=V/3^(1/2);
a=acosd(pf);                         //power factor angle of the load in degree
Ql=P*tand(a);                         //load reactive power in KVAR
Qtot=P*tand(acosd(pfnew));      //total reactive power for .95 power factor lagging
disp(Qtot,'The total reactive power for .95 power factor lagging in KVAR is')
Qm=Qtot-Ql;
Vt=(V/sqrt(3));
Ef=((Qm*Xs)/(3*Vt))+Vt;
If=Ef/c;
disp(If,'The excitation current required to improve overall power factor of the plant in A is')
```

Scilab code Exa 5.6 compute the minimum excitation that the machine must maintain

```
//Book name: Fundamentals of electrical drives by Mohamad A. El- Sharkawi
//chapter 5
//example 5.6
```

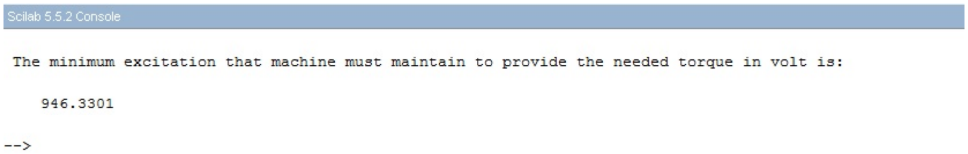


Figure 5.6: compute the minimum excitation that the machine must maintain to provide the needed torque

```
//edition 1
//publisher and place:Nelson Engineering
clc;
clear;
V=2300;                              //rated voltage of the synchronous motor in volt
Vt=V/3^(1/2);
f=60;                                //frequency in Hertz
p=6;                                 //number of poles
Tl=5000;                             //constant torque of the load in Nm
Xs=6;                                //synchronous reactance of the motor in ohm
ns=(120*f)/p;                        //synchronous speed of the motor in rpm
omegas=(2*%pi*ns)/60;
Ef=(Tl*omegas*Xs)/(3*Vt);            //The minimum excitation that machine must maintain to provide the needed torque
disp(Ef,'The minimum excitation that machine must maintain to provide the needed torque in volt is:')
```

Chapter 6

speed control of direct current motors

Scilab code Exa 6.1 calculate added resistance to reduce the speed by 50 percentag

```
//Book name: Fundamentals of electrical drives by Mohamad A. El- Sharkawi
//chapter 6
//example 6.1
//edition 1
//publisher and place:Nelson Engineering
clc;
clear;
Vs=150;//source voltage of DC shunt motor in volt
n1=1200;//synchronous speed in rpm
Ra=1;//armature resistance in ohm
Rf=150;//field resistance in ohm
I=10;//line current in ampere
If=(Vs/Rf);//Field current before adding the resistance in ampere
disp('a)Calculate the resistance that should be added to the armature circuit to reduce the speed
```

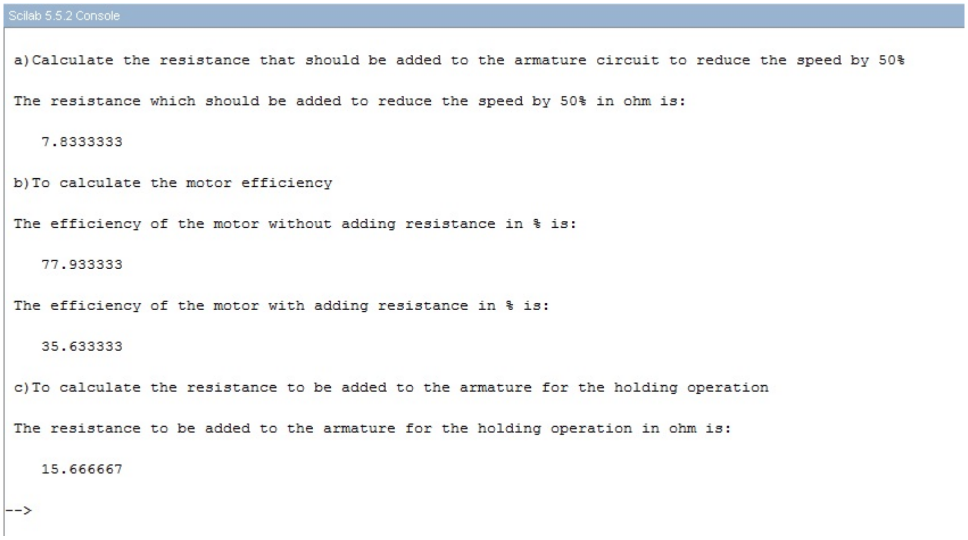


Figure 6.1: calculate added resistance to reduce the speed by 50 percentage and efficiency and resistance added to operate the motor in holding condition

```
    by 50%')
//consider that the motoring point 1 represents
    without adding resistance & point 2 for the
    operating point at 50% load reduction
Ia1=I-If;//armature current without adding
    resistance
n2=0.5*n1;//50% speed is reduced
Ea1=Vs-(Ia1*Ra);//speed equation at operating point
    1
Radd=Ea1/(2*Ia1);//Obtained from the equation of Ea1
    /Ea2=n1/n2
disp(Radd,'The resistance which should be added to
    reduce the speed by 50% in ohm is:')
disp('b)To calculate the motor efficiency')
Prloss=100;//rotational loss in watt
Pfloss=If^(2)*Rf;//field loss in watt
Paloss=Ia1^(2)*Ra//armature losses in watt
Pin=Vs*I;//Input power in watt
Ploss=Prloss+Pfloss+Paloss;//Total losses before
```

```
adding armature resistance in watt
Ploss1=Prloss+Pfloss+Paloss*(Ra+Radd);//Total losses after adding armature resistance in watt
eff=((Pin-Ploss)/Pin)*100;//efficiency of the motor without adding resistance in %
eff1=((Pin-Ploss1)/Pin)*100;//efficiency of the motor with adding resistance in %
disp(eff,'The efficiency of the motor without adding resistance in % is:')
disp(eff1,'The efficiency of the motor with adding resistance in % is:')
disp('c)To calculate the resistance to be added to the armature for the holding operation')
//set motor speed equal to zero
Radd=(Vs/Ia1)-Ra;
disp(Radd,'The resistance to be added to the armature for the holding operation in ohm is:')
```

Scilab code Exa 6.3 calculate armature current and motor speed and value of added

```
//Book name: Fundamentals of electrical drives by Mohamad A. El- Sharkawi
//chapter 6
//example 6.3
//edition 1
//publisher and place:Nelson Engineering
clc;
clear;
Vs=150;//source voltage of DC shunt motor in volt
n1=1200;//synchronous speed in rpm
Ra=2;//armature resistance in ohm
Rf=150;//field resistance in ohm
I=10;//line current in ampere
```

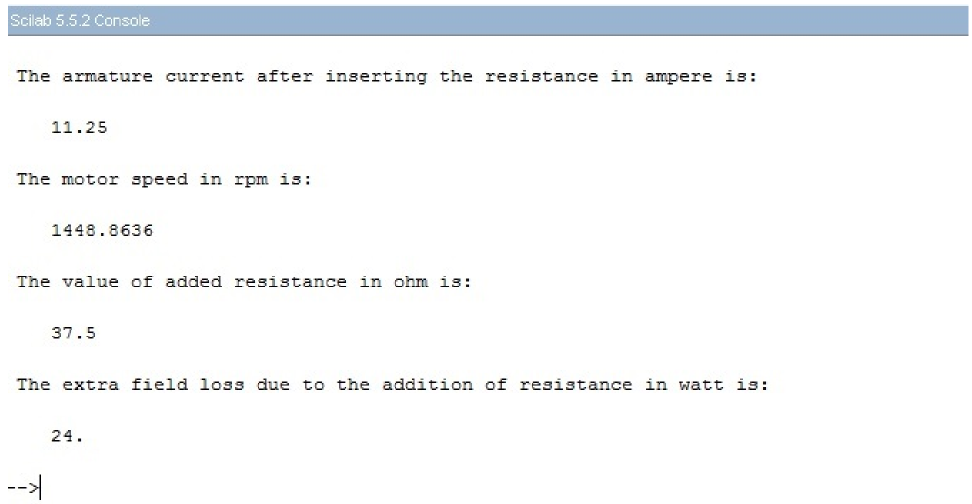


Figure 6.2: calculate armature current and motor speed and value of added resistance and extra field loss

```
If1=(Vs/Rf);//Field current before adding the resistance in ampere
//Assume the resistance added in the field circuit to reduce the field current by 20%
If2=.8;//Field current after adding the resistance in ampere
Ia1=I-If1;//Armature current before inserting the resistance in ampere
Ia2=(If1*Ia1)/If2;//Armature current after inserting the resistance in ampere
disp(Ia2,'The armature current after inserting the resistance in ampere is:')
Ea1=Vs-(Ia1*Ra);
Ea2=Vs-(Ia2*Ra);
n2=(If1*n1*Ea2)/(Ea1*If2);
disp(n2,'The motor speed in rpm is:')
Radd=(Vs-(If2*Rf))/If2;
disp(Radd,'The value of added resistance in ohm is:')
```

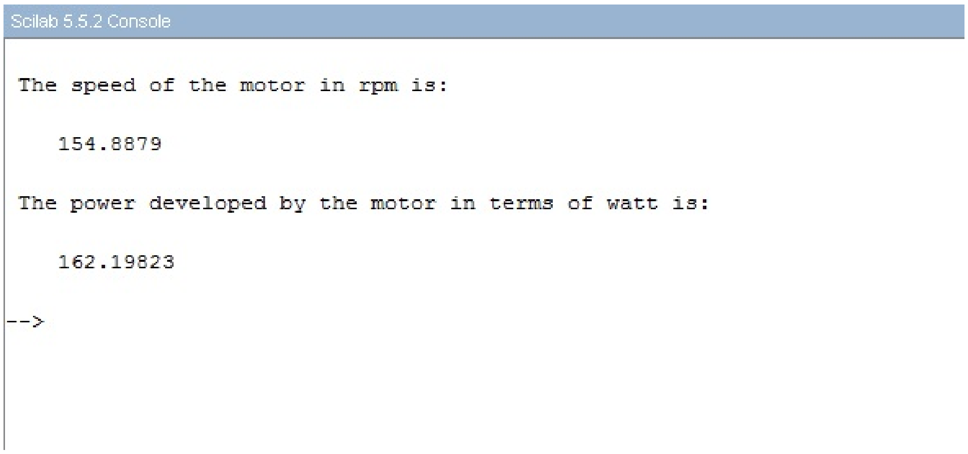


Figure 6.3: calculate the motor speed and the developed power

```
P=If2^(2)*Radd;
disp(P,'The extra field loss due to the addition of
   resistance in watt is:')
```

Scilab code Exa 6.4 calculate the motor speed and the developed power

```
//Book name: Fundamentals of electrical drives by
   Mohamad A. El- Sharkawi
//chapter 6
//example 6.4
//edition 1
//publisher and place:Nelson Engineering
clc;
clear;
L=1;//load of shunt motor in hp
T=10;//constant torque of motor in Nm
Ra=5;//armature resistance of the motor in ohm
KQ=2.5;//The field constant in V sec
```

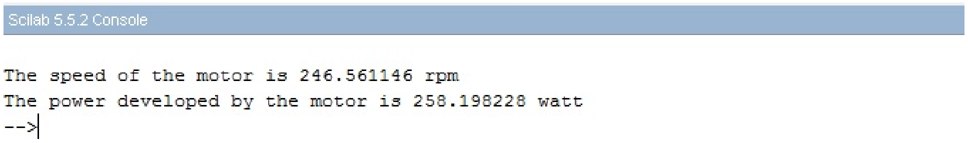


Figure 6.4: calculate the motor speed and the power delivered to the load

```
V=120;//source voltage in volt
f=60;//supply frequency in Hertz
a=60;//trigerring angle of the converter in degree
b=150;//conduction period in degree
Iave=T/KQ;//average current in ampere
Vm=V*2^(1/2);
W=((Vm/(2*%pi))*(cosd(a)-cosd(b+a))-(Iave*Ra))/((b/360)*KQ);//angular speed of the motor
n=W*(f/(2*%pi));
disp(n,'The speed of the motor in rpm is:')
Pd=KQ*W*Iave;//power developed by the motor
disp(Pd,'The power developed by the motor in terms of watt is:')
```

Scilab code Exa 6.5 calculate the motor speed and the power delivered to the load

```
//Book name: Fundamentals of electrical drives by Mohamad A. El- Sharkawi
//chapter 6
//example 6.5
//edition 1
//publisher and place:Nelson Engineering
clc;
```

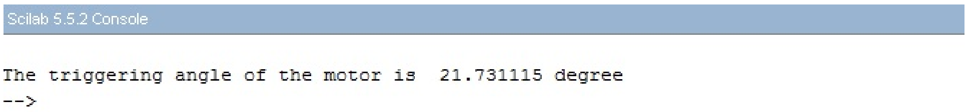


Figure 6.5: calculate the triggering angle of the motor

```
clear;
L=1;//load of shunt motor in hp
T=10;//constant torque of motor in Nm
Ra=5;//armature resistance of the motor in ohm
KQ=2.5;//The field constant in V sec
V=120;//source voltage in volt
f=60;//supply frequency in Hertz
a=60;//trigerring angle of the converter in degree
b=150;//conduction period in degree
Iave=T/KQ;//average current in amphere
Vm=V*2^(1/2);
W=((Vm/%pi)*(cosd(a)-cosd(b+a))-(Iave*Ra))/((b/180)*
   KQ);//angular speed of the motor
n=W*(60/(2*%pi));
mprintf("\nThe speed of the motor is %f rpm",n)
Pd=KQ*W*Iave;//power developed by the motor
mprintf("\nThe power developed by the motor is %f
   watt",Pd)
```

Scilab code Exa 6.6 `calculate the triggering angle of the motor`

```
//Book name: Fundamentals of electrical drives by
   Mohamad A. El- Sharkawi
//chapter 6
//example 6.6
```

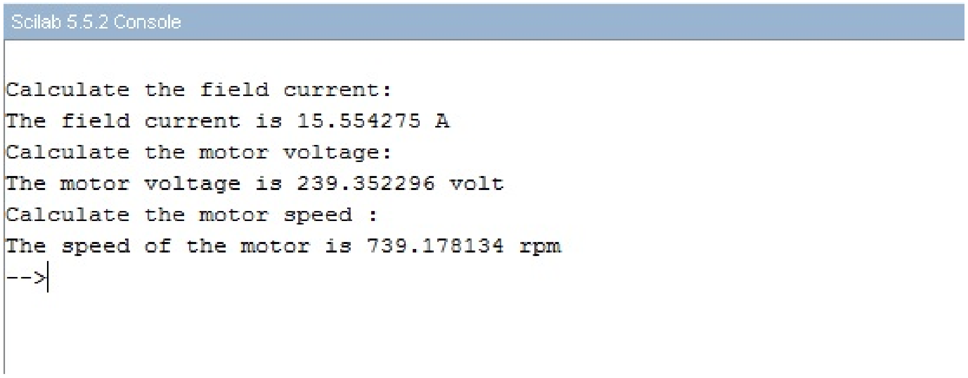


Figure 6.6: calculate field current motor voltage and speed

```
//edition 1
//publisher and place:Nelson Engineering
clc;
clear;
T=60;//Constant load torque in Nm
V=120;//supply voltage in volt
KQ=2.5;//Field constant of the motor
Ra=2;//Armature resistance in ohm
n=200;//speed of the motor in rpm
Vm=V*2^(1/2);//maximum voltage in volt
w=(2*%pi*n)/T;//angular speed
Iave=T/KQ;
b=((%pi/(2*Vm))*((Ra*Iave)+(KQ*w)));
alpha=acosd(b);
mprintf("\nThe triggering angle of the motor is  %f
   degree",alpha)
```

Scilab code Exa 6.7 calculate field current motor voltage and speed

```
//Book name: Fundamentals of electrical drives by
```

```
   Mohamad A. El- Sharkawi
//chapter 6
//example 6.7
//edition 1
//publisher and place:Nelson Engineering
clc;
clear;
Ra=2;//armature resistance in ohm
Rf=3;//field resistance in ohm
V=320;//terminal voltage in volt
T=60;//full load torque in Nm
n=600;//motor speed in rpm
mprintf("\nCalculate the field current:")
KC=0.248;//calculated by solving two equations
Ia=sqrt(T/KC);
mprintf("\nThe field current is %f A",Ia)
mprintf("\nCalculate the motor voltage:")
n1=400;
omega1=(2*%pi*n1)/T;
Vt=Ia*(Ra+Rf+(KC*omega1));
mprintf("\nThe motor voltage is %f volt",Vt)
mprintf("\nCalculate the motor speed :")
AR=Ra/Rf;
Ia=sqrt(T/(KC*AR));
w=(V/(KC*AR*Ia))-((Ra+(AR*Rf))/(KC*AR));
n2=(w*T)/(2*%pi);
mprintf("\nThe speed of the motor is %f rpm",n2)
```

Chapter 7

speed control of induction motors

Scilab code Exa 7.1 compute the added resistance to reduce the speed by 20 percent

```
//Book Name: Fundamentals of electrical drives by
   Mohamad A. El- Sharkawi
//chapter 7
//example 7.1
//edition 1
//publisher and place:Nelson Engineering
clc;
clear;
V=480;//terminal voltage in volt
p=6;//number of poles
f=60;//frequency in hertz
Pout=30*746;//rated output voltage in volts
R1=0.5;//stator resistance in ohm
R2=0.5;//rotor resistance reffered to stator in ohm
Protational=500;//rotational loss in watt
Pcu=600;//core losses in watt
c=0.05;//cost of energy
```

```
Scilab 5.5.2 Console

The speed of the motor is 1151 rpm
The efficiency of the motor without added resistance is 88 percentage
The resistance added to reduce 20 percentage of the speed is 2.359865 ohm
The efficiency of the motor with added resistance is 70 percentage
The annual cost of the operating motor is $1189.760000
-->
```

Figure 7.1: compute the added resistance to reduce the speed by 20 percent and motor efficiency with and without added resistance and annual cost of operating motor

```
t1=100;//time which the motor operates in a week
Pd=Pout+Protational;//developed power in watt
a=1;// the s^2 value from the equation s^2-s+0.039
b=-1;//the s value from the equation s^2-s+0.039
c=0.039;//the constant value from the equation s^2-s+0.039
s1=(-(b)+sqrt((b)^2-(4*a*c)))/(2*a);
s2=(-(b)-sqrt((b)^2-(4*a*c)))/(2*a);//roots to find the value of s from the equation s^2-s+0.03
s=s2;//s1 is very large hence neglected thus slip=s2
a1=120;//constant value in the formula
ns=(a1*f)/p;//synchronous speed in rpm
n=ns*(1-s);
mprintf("\nThe speed of the motor is %d rpm",n)
I2=sqrt((Pd*s)/(3*R2*(1-s)));//motor current in amps
Pwinding=3*I2^(2)*(R1+R2);
Pin=Pd+Pwinding+Pcu;
eta=Pout/Pin;//efficiency of the motor
eta=eta*100;//efficiency in percentage
mprintf("\nThe efficiency of the motor without added resistance is %d percentage",eta)
nnew=0.8*n;//speed after 20% reduction
snew=(ns-nnew)/ns;
rmsnew=nnew/60;//speed in rps
```

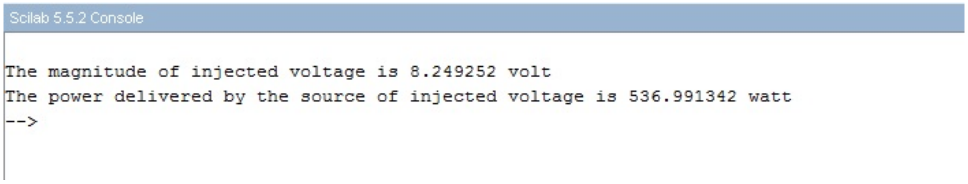


Figure 7.2: calculate the magnitude of the injected voltage and the power delivered by the source of injected voltage

```
omegadnew=(2*%pi*rmsnew);
rps=n/60;//speed in rps
omega=(2*%pi*rps);
Pdnew=(Pd*omegadnew)/omega;
Radd=R2*((snew-s)/s);//resistance added to reduce 20
   % of the speed
mprintf("\nThe resistance added to reduce 20
   percentage of the speed is %f ohm",Radd)
I2new=sqrt((Pdnew*snew)/(3*(R2+Radd)*(1-snew)))
Pwindingnew=3*I2^(2)*(R1+R2+Radd);
Pinnew=Pdnew+Pwindingnew+Pcu;
Poutnew=Pdnew-Protational;
etanew=Poutnew/Pinnew;
etanew=etanew*100;
mprintf("\nThe efficiency of the motor with added
   resistance is %d percentage",etanew)
Padd=3*I2^(2)*Radd;
Padd=Padd*10^(-3);
t=100*52;//total hours of operation in one year
C=Padd*t*c;
mprintf("\nThe annual cost of the operating motor is
    $%f",C)
//The answer may vary due to roundoff error
```

Scilab code Exa 7.2 calculate the magnitude of the injected voltage and the power

```
//Book Name: Fundamentals of electrical drives by
    Mohamad A. El- Sharkawi
//chapter 7
//example 7.2
//edition 1
//publisher and place:Nelson Engineering
clc;
clear;
V=480;//terminal voltage in volt
p=4;//number of poles
f=60;//frequency in hertz
Td=60;//constant torque load in Nm
R1=0.4;
R2=0.1;
Xeq=4;
N1=2;
N2=1;
n=1000;//speed of the motor in rpm
a1=120;
ns=(a1*f)/p;
s=(ns-n)/ns;
R21=R2*(N1/N2)^(2);
theta=atand(Xeq/(R1+(R21/s)));
a=0.05;
b=8;
c=-80.74;
Vi11=(-b+sqrt(8^2-(4*a*c)))/(2*a);//obtained from
    the equation 0.05Vi^2+8Vi-80.74
Vi12=(-b-sqrt(8^2-(4*a*c)))/(2*a);//obtained from
    the equation 0.05Vi^2+8Vi-80.74
Vi1=Vi11;//because negative voltage is neglected
Vi=(Vi1*N2)/N1;
c1=122;//calculated constant values of the equation
c2=1.85;//calculated constant values of the equation
I2=(c1-Vi1)/c2;
V1=sqrt(3)*Vi;//line to line injected voltage
```

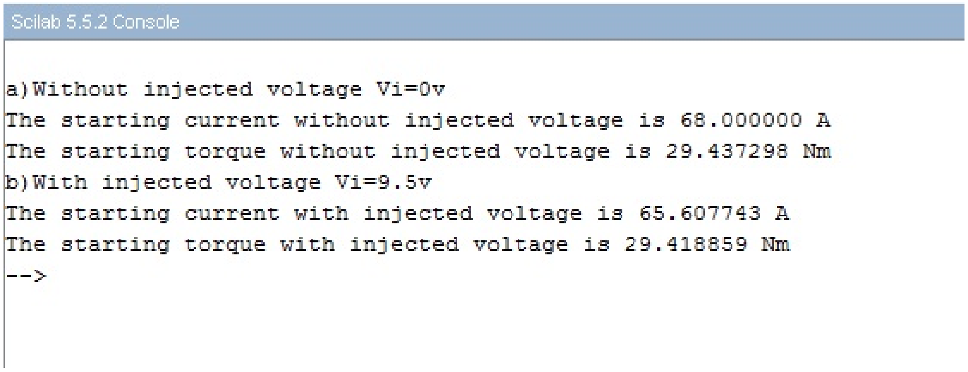


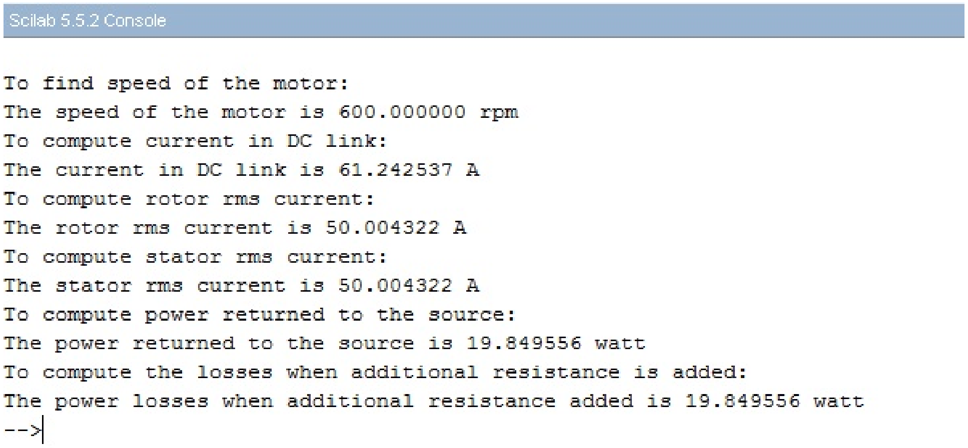
Figure 7.3: calculate the starting current and starting torque with and without the voltage

```
mprintf("\nThe magnitude of injected voltage is %f
    volt",V1)
Pr=3*I2*Vi1*cosd(theta);
mprintf("\nThe power delivered by the source of
    injected voltage is %f watt",Pr)
//The answers vary due to round off error
```

Scilab code Exa 7.3 calculate the starting current and starting torque with and wi

```
//Book Name: Fundamentals of electrical drives by
    Mohamad A. El- Sharkawi
//chapter 7
//example 7.3
//edition 1
//publisher and place:Nelson Engineering
clc;
clear;
V=480;//terminal voltage in volt
p=4;//number of poles
f=60;//frequency in hertz
```

```
Tl=60;//load torque in Nm
R1=0.4;
R2=0.1;
Xeq=4;
N1=2;//obtained from the equation N1/N2=2
n=1000;//motor speed in rpm
a=120;
ns=(a*f)/p;
rps=ns/60;
omegas=(2*%pi*rps);
mprintf("\na)Without injected voltage Vi=0v")
Vs=V/sqrt(3);
R21=R2*(N1^(2));
I2st=Vs/sqrt((R1+R21)^(2)+Xeq^(2));//starting
   current in A
I2st=ceil(I2st)//rounding off the starting current
Tst=(3*I2st^(2)*R1)/omegas;//staring torque
mprintf("\nThe starting current without injected
   voltage is %f A",I2st)
mprintf("\nThe starting torque without injected
   voltage is %f Nm",Tst)
mprintf("\nb)With injected voltage Vi=9.5v")
Vi=9.5;//injected voltage in volt
I2st1=(Vs-Vi)/sqrt((R1+R21)^(2)+Xeq^(2));//starting
   current with injected resistance in A
thetar=atand(Xeq/(R1+R21));
Tst1=(3/omegas)*((I2st1^2*R1)+(I2st*Vi)*cosd(thetar)
   );
mprintf("\nThe starting current with injected
   voltage is %f A",I2st1)
mprintf("\nThe starting torque with injected voltage
    is %f Nm",Tst1)
```



```
Scilab 5.5.2 Console

To find speed of the motor:
The speed of the motor is 600.000000 rpm
To compute current in DC link:
The current in DC link is 61.242537 A
To compute rotor rms current:
The rotor rms current is 50.004322 A
To compute stator rms current:
The stator rms current is 50.004322 A
To compute power returned to the source:
The power returned to the source is 19.849556 watt
To compute the losses when additional resistance is added:
The power losses when additional resistance added is 19.849556 watt
-->
```

Figure 7.4: calculate the motor speed and current in dc link and rotor and stator rms current and power returned back to the source and additional losses

Scilab code Exa 7.4 `calculate the motor speed and current in dc link and rotor and`

```
//Book Name: Fundamentals of electrical drives by
   Mohamad A. El- Sharkawi
//chapter 7
//example 7.4
//edition 1
//publisher and place:Nelson Engineering
clc;
clear;
V=480;//terminal voltage in volt
p=6;//number of poles
f=60;//frequency in hertz
Tout=300;//constant load torque in Nm
N1=1;
N2=1;
Prot=1e3;//rotational power in watt
alpha=120;//trigerring angle in degree
mprintf("\nTo find speed of the motor:")
```

```
a=120;//constant value
ns=(a*f)/p;
n=ns*(1+((N1/N2)*cosd(alpha)));
mprintf("\nThe speed of the motor is %f rpm",n)
s=(ns-n)/ns;
mprintf("\nTo compute current in DC link:")
rps=n/60;//speed in rps
omega=(2*%pi*rps);
Pout=Tout*omega;
Pd=Pout+Prot;
K=(3*sqrt(2))/%pi;
I=(Pd/(1-s))/(K*V);
mprintf("\nThe current in DC link is %f A",I)
mprintf("\nTo compute rotor rms current:")
itr=sqrt(2/3);//solved integration value
I2=itr*I;
mprintf("\nThe rotor rms current is %f A",I2)
mprintf("\nTo compute stator rms current:")
I1=(N1/N2)*I2
mprintf("\nThe stator rms current is %f A",I1)
mprintf("\nTo compute power returned to the source:")
Pr=Pd;
Pr=Pr*10^(-3);
mprintf("\nThe power returned to the source is %f watt",Pr)
mprintf("\nTo compute the losses when additional resistance is added:")
Td=Pd/omega;
rpss=ns/60;//speed in rps
omegas=(2*%pi*rpss);
Radd=(V^2*s)/(Td*omegas);//additional resistance added in ohm
I2=sqrt(((s/(1-s))*(Pd/3))/Radd);//rotor current
Padd=3*I2^2*Radd;//additional power loss
Padd=Padd*10^(-3);
mprintf("\nThe power losses when additional resistance added is %f watt",Padd)
```

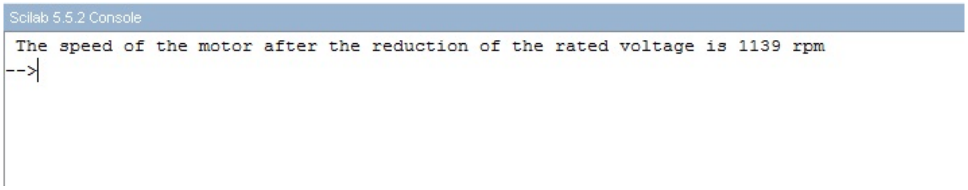
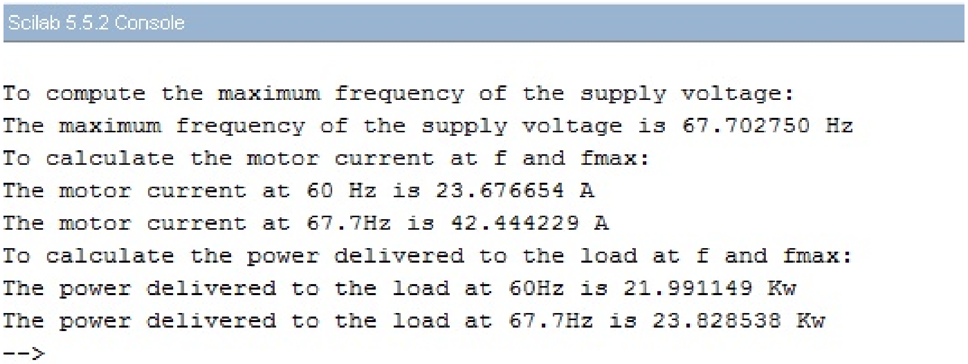


Figure 7.5: calculate the motor speed at full voltage

Scilab code Exa 7.5 `calculate the motor speed at full voltage`

```
//Book Name: Fundamentals of electrical drives by
   Mohamad A. El- Sharkawi
//chapter 7
//example 7.5
//edition 1
//publisher and place:Nelson Engineering
clc;
clear;
V=480;//terminal voltage in volt
p=6;//number of poles
Pout=30*746;//output power interms of watt
f=60;//frequency in hertz
R1=0.5;//stator resistance in ohm
R2=0.5;//rotor resistance reffered to stator in ohm
ns=1200;//synchronus speed in rpm
rps=ns/60;
omegas=(2*%pi*rps);//angular synchronous speed
Td=120;//load torque constant
s=(Td*omegas*R2)/V^2;
n=ns*(1-s);//the speed at full voltage in rpm
n=ceil(n)
Vnew=0.8*V;//when voltage is reduced by 20%
```



```
Scilab 5.5.2 Console

To compute the maximum frequency of the supply voltage:
The maximum frequency of the supply voltage is 67.702750 Hz
To calculate the motor current at f and fmax:
The motor current at 60 Hz is 23.676654 A
The motor current at 67.7Hz is 42.444229 A
To calculate the power delivered to the load at f and fmax:
The power delivered to the load at 60Hz is 21.991149 Kw
The power delivered to the load at 67.7Hz is 23.828538 Kw
-->
```

Figure 7.6: compute maximum frequency and then motor current and power delivered at 60 Hz and at maximum frequency

```
snew=(V^2*s)/Vnew^2;//new slip after the reduction
    of 20% of the rated voltage
nnew=ns*(1-snew);//new speed of the motor in rpm
nnew=ceil(nnew)
mprintf("The speed of the motor after the reduction
    of the rated voltage is %d rpm",nnew)
```

Scilab code Exa 7.6 compute maximum frequency and then motor current and power del

```
//Book Name: Fundamentals of electrical drives by
    Mohamad A. El- Sharkawi
//chapter 7
//example 7.6
//edition 1
//publisher and place:Nelson Engineering
clc;
clear;
V=480;//terminal voltage in volt
```

```
p=2;//number of poles
f=60;//frequency in hertz
Xeq=4;//inductive reactance in ohm
R1=0.2;//stator resistance in ohm
R2=0.3;//rotor resistance reffered to stator in ohm
Td=60;//driving constant load torque in Nm
n=3500;//speed of the motor in rpm
a=120;//constant value
ns=(a*f)/p;//synchronous speed in rpm
mprintf("\nTo compute the maximum frequency of the supply voltage:")
Tmax=Td;
rpss=ns/60;
omegas=(2*%pi*rpss);
fmax=sqrt((V^2*f^2)/(Tmax*2*omegas*4));
mprintf("\nThe maximum frequency of the supply voltage is %f Hz",fmax)
mprintf("\nTo calculate the motor current at f and fmax:")
s=(ns-n)/ns;//slip at 60Hz
Vs=V/sqrt(3);
I2=Vs/sqrt((R1+(R2/s))^2+Xeq^2);
mprintf("\nThe motor current at 60 Hz is %f A",I2)
Xeqmax=(fmax/f)*Xeq;
smax=R2/sqrt(R1^2+Xeqmax^2);
nmax=((a*fmax)/p)*(1-smax);
I2max=Vs/sqrt((R1+(R2/smax))^2+Xeqmax^2);
mprintf("\nThe motor current at 67.7Hz is %f A",I2max)
mprintf("\nTo calculate the power delivered to the load at f and fmax:")
rps=n/60;
omega=(2*%pi*rps);
Pd=Td*omega;//developed power at 60Hz
Pd=Pd*10^(-3);//developed power in kilowatt
mprintf("\nThe power delivered to the load at 60Hz is %f Kw",Pd)
rpsmax=nmax/60;
```

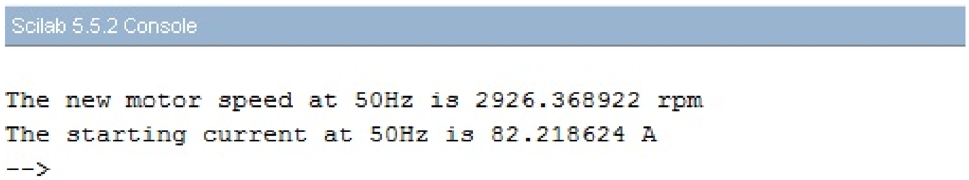


Figure 7.7: compute the motor speed and the starting current if the frequency decreased to 50 Hz

```
omegamax=(2*%pi*rpsmax);
Pdmax=Td*omegamax;//developed power at 67.7Hz
Pdmax=Pdmax*10^(-3);//developed power in kilowatt
mprintf("\nThe power delivered to the load at 67.7Hz is %f Kw",Pdmax)
```

Scilab code Exa 7.7 compute the motor speed and the starting current if the freque

```
//Book Name: Fundamentals of electrical drives by Mohamad A. El- Sharkawi
//chapter 7
//example 7.7
//edition 1
//publisher and place:Nelson Engineering
clc;
clear;
V=480;//terminal voltage in volt
p=2;//number of poles
fst=60;//frequency in hertz
f=50;//decreased frequency in Hz
Xeq=4;//inductive reactance in ohm
R1=0.2;//stator resistance in ohm
R2=0.3;//rotor resistance reffered to stator in ohm
```

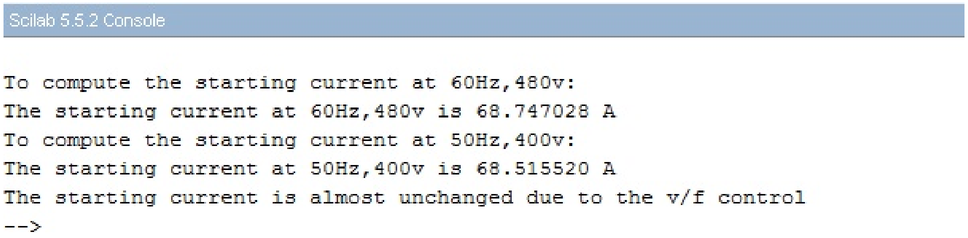


Figure 7.8: compute the starting current for a constant v by f control

```
Td=60;//driving constant load torque in Nm
n=3500;//speed of the motor in rpm
ns=(120*f)/p;//synchronous speed in rpm
Vs=V/sqrt(3);
rps=ns/60;
omegas=(2*%pi*rps);
s=(Td*omegas*R2)/V^2;
n=ns*(1-s);//the new motor speed at 50Hz in rpm
mprintf("\nThe new motor speed at 50Hz is %f rpm",n)
I2st=Vs/sqrt((R1+R2)^(2)+Xeq^(2));//starting current
    in A
Xeqnew=(f/fst)*Xeq;//inductive reactance at 50Hz
I2stnew=Vs/sqrt((R1+R2)^(2)+Xeqnew^(2));//starting
    current at 50Hz in A
mprintf("\nThe starting current at 50Hz is %f A",
    I2stnew)
```

Scilab code Exa 7.8 compute the starting current for a constant v by f control

```
//Book Name: Fundamentals of electrical drives by
    Mohamad A. El- Sharkawi
//chapter 7
```

```
//example 7.8
//edition 1
//publisher and place:Nelson Engineering
clc;
clear;
V=480;//terminal voltage in volt
p=2;//number of poles
f=60;//frequency in hertz
fd=50;//decreased frequency in Hz
Xeq=4;//inductive reactance in ohm
R1=0.2;//stator resistance in ohm
R2=0.3;//rotor resistance reffered to stator in ohm
Td=60;//driving constant load torque in Nm
n=3500;//speed of the motor in rpm
VFR=V/f;//voltage frequency ratio
Vnew=fd*VFR;
a=120;//constant value
ns=(a*fd)/p;//synchronous speed in rpm
Vs=V/sqrt(3);
rps=n/60;
omegas=(2*%pi*rps);
s=(Td*omegas*R2)/Vnew^2;
n=ns*(1-s);//the new motor speed at 50Hz in rpm
rpss=ns/60;
omega=(2*%pi*rpss)/60;
mprintf("\nTo compute the starting current at 60Hz,480v:")
I2st=Vs/sqrt((R1+R2)^(2)+Xeq^(2));//starting current in A
mprintf("\nThe starting current at 60Hz,480v is %f A",I2st)
mprintf("\nTo compute the starting current at 50Hz,400v:")
Vsnew=Vnew/sqrt(3);
Xeqnew=(fd/f)*Xeq;//inductive reactance at 50Hz
I2stnew=Vsnew/sqrt((R1+R2)^(2)+Xeqnew^(2));//starting current at 50Hz in A
mprintf("\nThe starting current at 50Hz,400v is %f A
```

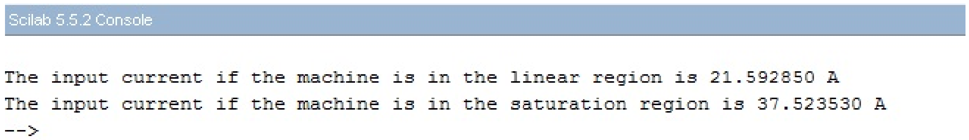


Figure 7.9: compute the input current

```
    ",I2stnew)
mprintf("\nThe starting current is almost unchanged
    due to the v/f control")
```

Scilab code Exa 7.9 compute the input current

```
//Book Name: Fundamentals of electrical drives by
    Mohamad A. El- Sharkawi
//chapter 7
//example 7.9
//edition 1
//publisher and place:Nelson Engineering
clc;
clear;
V=480;//terminal voltage in volt
p=6;//number of poles
f=60;//frequency in hertz
X1=3;//inductive reactance in ohm
Rs=.2;//stator resistance in ohm
X2=2;//rotor reactance in ohm
R2=0.1;//resistance reffered to the stator in ohm
Xm=120;//magnetizing reactance in the linear region
    in ohm
Xm1=42;//magnetizing reactance in the saturation
    region in ohm
```

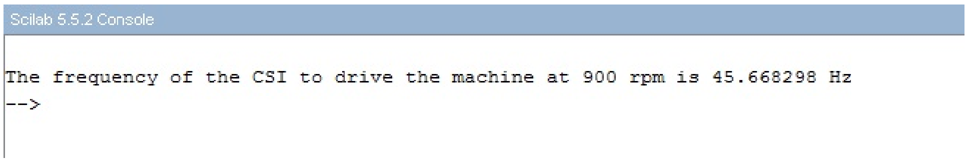


Figure 7.10: compute the frequency of the CSI to drive the machine at 900 rpm

```
Td=100;//constant load torque in Nm
n=900;//speed of the motor in rpm
ns=(120*f)/p;//synchronous speed of the machine in
    rpm
s=(ns-n)/ns;//slip of the machine
//If the machine is in the linear region
rps=ns/60;
omegas=(2*%pi*rps);
Is=sqrt(((Td*s*omegas)*((R2/s)^2+(X2+Xm)^2))/(3*Xm
    ^2*R2));
costheta=0.7;//assumed power factor value
I1rated=(Td*omegas)/(sqrt(3)*V*costheta);
mprintf("\nThe input current if the machine is in
    the linear region is %f A",I1rated)
//if the machine is in saturation region
Is1=sqrt(((Td*s*omegas)*((R2/s)^2+(X2+Xm1)^2))/(3*Xm
    ^2*R2));
mprintf("\nThe input current if the machine is in
    the saturation region is %f A",Is1)
```

Scilab code Exa 7.10 compute the frequency of the CSI to drive the machine at 900

```
//Book Name: Fundamentals of electrical drives by
    Mohamad A. El- Sharkawi
//chapter 7
```

```
//example 7.10
//edition 1
//publisher and place:Nelson Engineering
clc;
clear;
V=480;                              //terminal voltage in volt
p=6;                               //number of poles
f=60;                             //frequency in hertz
Xl=3;                            //inductive reactance in ohm
Rs=.2;                          //stator resistance in ohm
X2=2;                          //rotor reactance in ohm
R2=0.1;                       //resistance reffered to the stator in ohm
Xm=120;                      //magnetizing reactance in the linear region in ohm
Xm1=42;                     //magnetizing reactance in the saturation region in ohm
Td=100;                   //constant load torque in Nm
n=900;                   //speed of the motor in rpm
Is=21.6;
rps=n/60;
omega=(2*%pi*rps);
f=(((3*Is^(2)*R2)/((2*%pi*Td)/f))+n)*(p/Xm);
mprintf("\nThe frequency of the CSI to drive the machine at 900 rpm is %f Hz",f)
```

Chapter 9

Braking of dc motors

Scilab code Exa 9.1 `calculate no load and motor speed then developed torque and Ea`

```
//Book name: Fundamentals of electrical drives by
   Mohamad A. El- Sharkawi
//chapter 9
//example 9.1
//edition 1
//publisher and place:Nelson Engineering
clc;
clear;
V=440;//source voltage in volt
Ia=76;//armature current in ampere
ns=1000;//speed of the DC shunt motor in rpm
Ra=.377;//armature resistance of the motor in ohm
Rf=110;//field resistance of the motor in ohm
Prloss=1000;//rotational losses in watt
se=60;//seconds for 1 minute
Ea=V-(Ra*Ia);
rps=ns/se;
omega=(2*%pi*rps);//angular speed of the motor
KQ=Ea/omega;//field constant
```

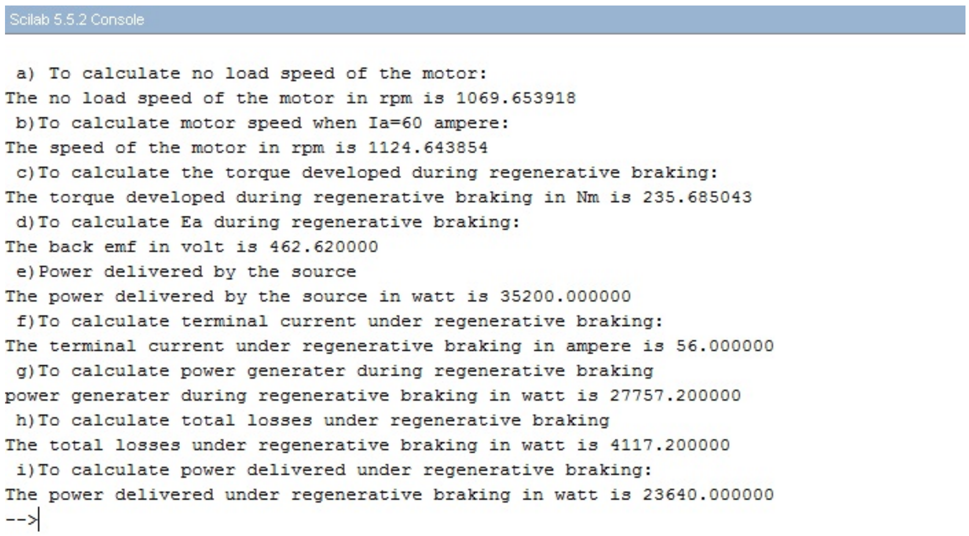


Figure 9.1: calculate no load and motor speed then developed torque and Ea and terminal current and total losses during regenerative braking and also power delivered

```
disp('a) To calculate no load speed of the motor:')
omegao=V/KQ;//angular no load speed
no=(omegao*se)/(2*%pi);
mprintf("The no load speed of the motor in rpm is %f
   ",no)
disp('b)To calculate motor speed when Ia=60 ampere:'
   )
Ia3=60;
omega3=(V+(Ra*Ia3))/KQ;
n3=(omega3*se)/(2*%pi);
mprintf("The speed of the motor in rpm is %f",n3)
disp('c)To calculate the torque developed during
   regenerative braking:')
Tl3=KQ*Ia3;
mprintf("The torque developed during regenerative
   braking in Nm is %f",Tl3)
disp('d)To calculate Ea during regenerative braking:
   ')
```

```
Ea3=KQ*omega3;
mprintf("The back emf in volt is %f",Ea3)
disp('e)Power delivered by the source')
If=V/Rf;
I1=Ia+If;
Ps=I1*V;
mprintf("The power delivered by the source in watt is %f",Ps)
disp('f)To calculate terminal current under regenerative braking:')
I3=Ia3-If;
mprintf('The terminal current under regenerative braking in ampere is %f',I3)
disp('g)To calculate power generater during regenerative braking')
Pg=Ea3*Ia3;
mprintf("power generater during regenerative braking in watt is %f",Pg)
disp('h)To calculate total losses under regenerative braking')
Ploss=(Ra*(Ia3^(2)))+((V^(2))/Rf)+Prloss;
mprintf("The total losses under regenerative braking in watt is %f",Ploss)
disp('i)To calculate power delivered under regenerative braking:')
Pd=Pg-Ploss;
mprintf("The power delivered under regenerative braking in watt is %f",Pd)
```

Scilab code Exa 9.2 calculate the speed

```
//Book name: Fundamentals of electrical drives by Mohamad A. El- Sharkawi
```

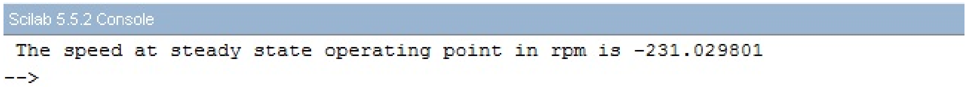


Figure 9.2: calculate the speed

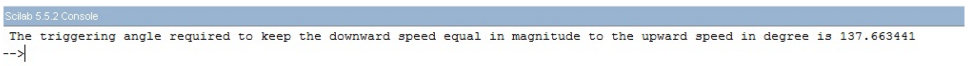


Figure 9.3: calculate the triggering angle

```
//chapter 9
//example 9.2
//edition 1
//publisher and place:Nelson Engineering
clc;
clear;
Ib=40;//current of the motor in ampere
Rb=2;//braking resistance in ohm
Ra=0.377;//armature resistance in ohm
KQ=3.93;//field constant
omega=-(Ib*(Ra+Rb))/KQ;//angular speed in rad/sec
se=60;//seconds in 1 minute
n=omega*(se/(2*%pi));
mprintf("The speed at steady state operating point
    in rpm is %f",n)
```

Scilab code Exa 9.3 calculate the triggering angle

```
//Book name: Fundamentals of electrical drives by
    Mohamad A. El- Sharkawi
//chapter 9
```

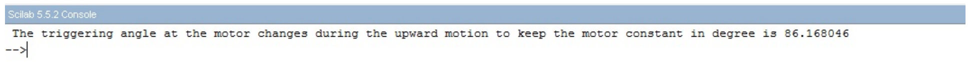


Figure 9.4: calculate the triggering angle

```
//example 9.3
//edition 1
//publisher and place:Nelson Engineering
clc;
clear;
Ra=.5;//armature resistance in ohm
KQ=3;//field constant
V=277;//source voltage in volt
Tup=100;//upward directional load torque in Nm
a=20;//triggering angle in degree
Tdw=200;//downward directional load torque in Nm
Vm=V*sqrt(2);
Veq=((2*Vm)/%pi)*cosd(a);
omega1=((Veq/KQ))-((Ra*Tup)/KQ^(2));
n1=omega1*(60/(2*%pi));//downward speed in rpm
b1=((-KQ*omega1)+((Ra*Tdw)/KQ))/((2*Vm)/%pi);
alpha2=acosd(b1);
mprintf("The triggering angle required to keep the
    downward speed equal in magnitude to the upward
    speed in degree is %f",alpha2)
```

Scilab code Exa 9.4 calculate the triggering angle

```
//Book name: Fundamentals of electrical drives by
    Mohamad A. El- Sharkawi
//chapter 9
//example 9.4
//edition 1
```

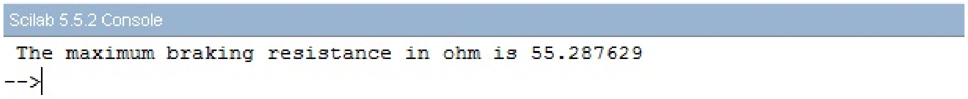


Figure 9.5: calculate the value of braking resistance

```
//publisher and place:Nelson Engineering
clc;
clear;
Ra=.5;//armature resistance in ohm
KQ=3;//field constant
V=277;//source voltage in volt
Tup=100;//upward directional load torque in Nm
Vm=V*sqrt(2);
b1=((Ra*Tup)/KQ)/((2*Vm)/%pi);
alpha3=acosd(b1);//triggering angle at the upward motion
mprintf("The triggering angle at the motor changes during the upward motion to keep the motor constant in degree is %f",alpha3)
```

Scilab code Exa 9.5 calculate the value of braking resistance

```
//Book name: Fundamentals of electrical drives by Mohamad A. El- Sharkawi
//chapter 9
//example 9.5
//edition 1
//publisher and place:Nelson Engineering
clc;
clear;
```

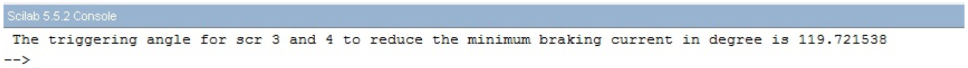


Figure 9.6: calculate the triggering angle

```
Ra=1;//armature resistance in ohm
KQ=3;//field constant
V=320;//Terminal voltage in volts
n=1000;//motor speed in rpm
omega=(2*%pi*n)/60;
Ea1=KQ*omega;
Ia=(V-Ea1)/Ra;//normal field current in ampere
Ib=2*Ia;//maximum braking current which is twice the armature voltage in A
Rb=-(V+Ea1+(Ib*Ra))/Ib;//braking resistance
Rb=abs(Rb);
mprintf("The maximum braking resistance in ohm is %f",Rb)
//the answer given in the book is wrong
```

Scilab code Exa 9.6 calculate the triggering angle

```
//Book name: Fundamentals of electrical drives by Mohamad A. El- Sharkawi
//chapter 9
//example 9.6
//edition 1
//publisher and place:Nelson Engineering
clc;
clear;
Ra=1;//armature resistance in ohm
KQ=3;//field constant
V=480;//Terminal voltage in volts
```

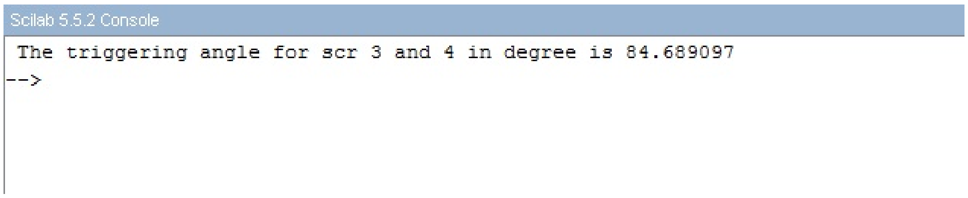


Figure 9.7: calculate the triggering angle

```
Tl=120;//load torque in Nm
alpha=30;//triggering angle of SCR 1 and 2
Vm=V*sqrt(2);
Iave1=Tl/KQ;
omega1=(((2*Vm)/%pi)*cosd(alpha)-(Iave1*Ra))/KQ;
se=60;//seconds in one minute
n1=(omega1*se)/(2*%pi);
Ib=-3*Iave1;
b1=-((KQ*omega1)-(3*Iave1))/((2*Vm)/%pi);
alpha2=acosd(b1);
mprintf("The triggering angle for scr 3 and 4 to
    reduce the minimum braking current in degree is
    %f",alpha2)
```

Scilab code Exa 9.7 calculate the triggering angle

```
//Book name: Fundamentals of electrical drives by
    Mohamad A. El- Sharkawi
//chapter 9
//example 9.7
//edition 1
//publisher and place:Nelson Engineering
clc;
clear;
Ra=1;//armature resistance in ohm
```

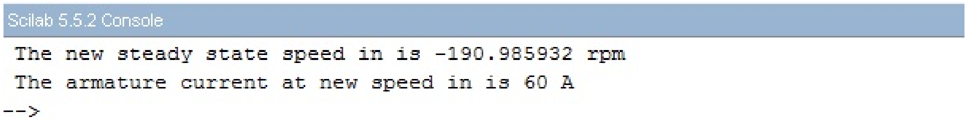


Figure 9.8: calculate new steady state speed and the armature current

```
KQ=3;//field constant
V=480;//Terminal voltage in volts
Tl=120;//load torque in Nm
Vm=V*sqrt(2);
Iave1=Tl/KQ;
omega3=0;//motor speed at holding condition
Iave3=-Iave1;
b1=((KQ*omega3)+(Ra*Iave3))/-((2*Vm)/%pi);
alpha2=acosd(b1);
mprintf("The triggering angle for scr 3 and 4 in degree is %f",alpha2)
```

Scilab code Exa 9.8 calculate new steady state speed and the armature current

```
//Book name: Fundamentals of electrical drives by Mohamad A. El- Sharkawi
//chapter 9
//example 9.8
//edition 1
//publisher and place:Nelson Engineering
clc;
clear;
Ra=0.5;//armature resistance in ohm
```

```
KQ=3;//field resistance
V=200;//source voltage in volt
T=180;//troque of the forklift in Nm
V1=-30;//terminal voltage of the motor in volt
omega5=((V1/KQ))-((Ra*T)/KQ^(2));
se=60;//seconds in one minute
n5=omega5*(se/(2*%pi));//new steady state speed at point 5 in rpm
mprintf("The new steady state speed in is %f rpm",n5)
I5=(V1-(KQ*omega5))/Ra;//current at point 5
mprintf("\n The armature current at new speed in is %d A",I5)
```

Chapter 10

Braking of induction motors

Scilab code Exa 10.1 calculate motor speed and power delivered to the electrical s

```
//Book name: Fundamentals of electrical drives by Mohamad A. El- Sharkawi
//chapter 10
//example 10.1
//edition 1
//publishing place:Thomson Learning
clc;
clear;
V=208;//source voltage in volts
p=6;//number of poles
R1=0.6;//given resistance in ohm
R2=0.4;//given R'2 in ohm
Xeq=5;//given Xeq in ohm
Td=30;//load torque of the motor in ohm
f=60;//frequency for 3 phase line
ns=(120*f)/p
disp('a)To find the regenerative speed:')
Tl=-Td//reversed load torque
rpss=ns/60;
```

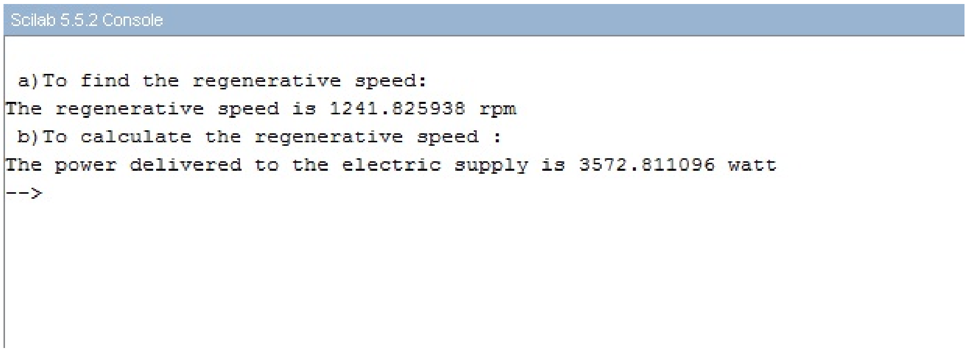


Figure 10.1: calculate motor speed and power delivered to the electrical supply

```
omegas=(2*%pi*rpss);//angular speed
s=(Tl*omegas*R2)/V^2;
n=ns*(1-s);
mprintf("The regenerative speed is %f rpm",n)
disp('b)To calculate the regenerative speed :')
rps=n/60;
omega=(2*%pi*rps);
Pd=Td*omega;
I2=sqrt(-Pd/(3*(R2/s)*(1-s)));//to find I'2 which is taken as I2
Ploss=3*(R1+R2)*I2'^(2)
Pds=Pd-Ploss;
mprintf("The power delivered to the electric supply is %f watt",Pds)
```

Scilab code Exa 10.2 calculate the duty ratio of the FWM

```
//Book name: Fundamentals of electrical drives by Mohamad A. El- Sharkawi
//chapter 10
```

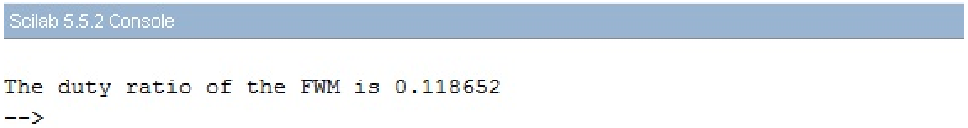


Figure 10.2: calculate the duty ratio of the FWM

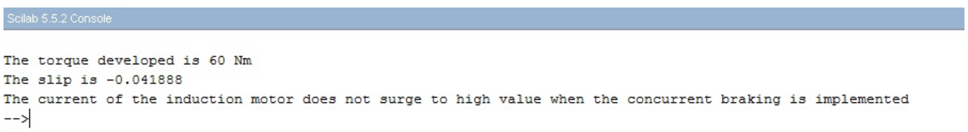


Figure 10.3: calculate slip and current and also torque at all operating points

```
//example 10.2
//edition 1
//publishing place:Thomson Learning
clc;
clear;
Vdc=200;//voltage at the dc link in volt
I=25;//motor current in A
R1=0.5;//stator resistance in ohm
Ib=3*I;
Vb=Ib*1.5*R1;//braking voltage in volt
d=1.5*(Vb/Vdc)^2;
mprintf("\nThe duty ratio of the FWM is %f",d)
```

Scilab code Exa 10.3 calculate slip and current and also torque at all operating p

```
//Book Name: Fundamentals of electrical drives by Mohamad A. El- Sharkawi
//chapter 10
//example 10.3
//edition 1
//publishing place:Thomson Learning
clc;
clear;
n1=1150;//full load speed in rpm
V=300;//terminal voltage in volt
f=80;//frequency in Hz
Rr=0.5;//rotor resistance of the motor in ohm
Xeq=3;//equivalent inductive reactance in ohm
ns=1200;//nearest synchronous speed in rpm
rpss=ns/60;
omegas=(2*%pi*rpss);
s1=(ns-n1)/ns;
T6=(V^(2)*s1)/(omegas*Rr);//torque at the point 6
T6=ceil(T6);
mprintf("\nThe torque developed is %d Nm",T6)//approximated value
s6=(T6*Rr*(-omegas))/V^(2);
mprintf("\nThe slip is %f",s6)
n6=(-ns)*(1-s6);
mprintf("\nThe current of the induction motor does not surge to high value when the concurrent braking is implemented")
```

Chapter 11

Dynamics of electric drive systems

Scilab code Exa 11.1 calculate the motor speed

```
//Book Name: Fundamentals of electrical drives by
   Mohamad A. El- Sharkawi
//chapter 11
//example 11.1
//edition 1
//publisher and place:Nelson Engineering
clc;
```

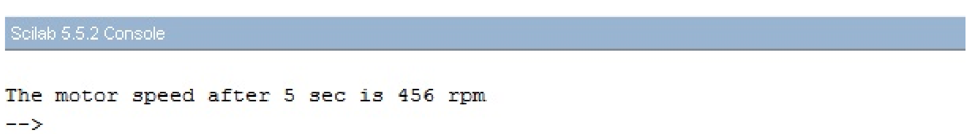


Figure 11.1: calculate the motor speed

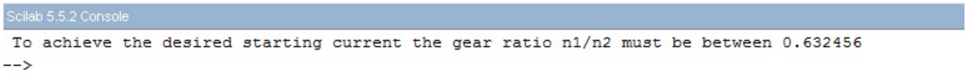


Figure 11.2: calculate and show how to achieve the desired starting time

```
clear;
Kphi=3;                         //constant in Vsec
Ra=1;                          //resistance in ohm
La=10;                        //inductance in mH
V=600;                        //rated voltage of the motor in volt
Vt=150;                      //starting voltage in volt
Tl=20;                     //constant torque in Nm
m=6;                       //total moment of inertia in Nm sec^2
omegaf=(Vt/Kphi)-((Ra*Tl)/Kphi^(2));
nf=(omegaf*60)/(2*%pi);
mprintf("\nThe motor speed after 5 sec is %d rpm",nf)
//The plot obtained in the book is using a simulation software using specific design that is avaliable in the software.In scilab or xcos there is no option to simulate DC shunt motor
```

Scilab code Exa 11.3 calculate and show how to achieve the desired starting time

```
//Book Name: Fundamentals of electrical drives by Mohamad A. El- Sharkawi
//chapter 11
//example 11.3
//edition 1
```

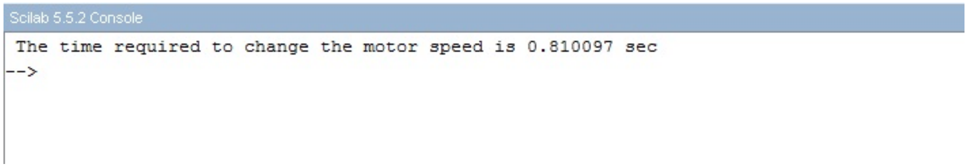


Figure 11.3: calculate the time required to change the motor speed

```
//publishing place:Thomson Learning
clc;
clear;
Ra=2;//armature resistance in ohm
Tst1=2;//limited starting time in sec
Kphi=3;//field constant in V sec
Jm=1;//motor moment of inertia in Nm
Jl=5;//load moment of inertia in Nm
tau=((Jl+Jm)*Ra)/Kphi^(2);
Tst=3*tau;//starting time of the motor based on given data in sec
Jeq=(Tst1*(Kphi^(2)))/(3*Ra);
gr=sqrt((Jeq-Jm)/Jl);//gear ratio n1/n2
mprintf("To achieve the desired starting current the gear ratio n1/n2 must be between %f",gr)
```

Scilab code Exa 11.4 calculate the time required to change the motor speed

```
//Book Name: Fundamentals of electrical drives by Mohamad A. El- Sharkawi
//chapter 11
//example 11.4
//edition 1
//publishing place:Thomson Learning
clc;
clear;
```

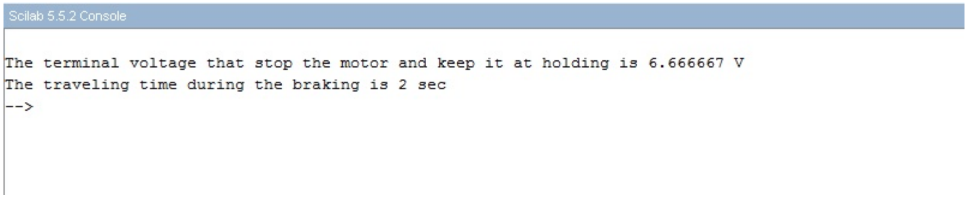


Figure 11.4: calculate terminal voltage and traveling time during braking

```
Ra=1;//armature resistance in ohm
Kphi=3;//field constant in V sec
Vt=500;//terminal voltage in volt
Vf=600;//increased motor voltage in volt
Td=20;//constant torque of thmotor in Nm
J=6;//total moment of inertia of the drive in Nm
omega0=(Vt/Kphi)-((Ra*Td)/Kphi^(2));//initial speed
    in rad/sec
omegaf=(Vf/Kphi)-((Ra*Td)/Kphi^(2));//final speed in
    rad/sec
tau=(J*Ra)/Kphi^(2);
t=-(tau*log((0.05*omegaf)/(omegaf-omega0)));//
    obtained from the equation of omega=omega(f)(1-e
    ^-t/tau)+omega(0)e^-t/tau
mprintf("The time required to change the motor speed
    is %f sec",t)
```

Scilab code Exa 11.5 calculate terminal voltage and traveling time during braking

```
//Book Name: Fundamentals of electrical drives by
   Mohamad A. El- Sharkawi
//chapter 11
//example 11.5
//edition 1
//publishing place:Thomson Learning
```

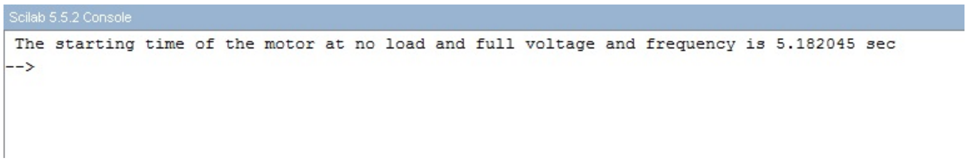


Figure 11.5: compute the starting time of the motor at no load and full load voltage

```
clc;
clear;
Ra=1;//armature resistance in ohm
Kphi=3;//field constant in V sec
Vt=500;//terminal voltage in volt
Td=20;//constant torque of the motor in Nm
J=6;//total moment of inertia of the drive in Nm
omegaf=0;
Vb=(omegaf+((Ra*Td)/Kphi^(2)))*Kphi;
mprintf("\nThe terminal voltage that stop the motor and keep it at holding is %f V",Vb)
tau=(J*Ra)/Kphi^(2);
t=3*tau;//the motor reaches the holding state when speed is 5% of initial speed
mprintf("\nThe traveling time during the braking is %d sec",t)
```

Scilab code Exa 11.6 compute the starting time of the motor at no load and full lo

```
//Book Name: Fundamentals of electrical drives by Mohamad A. El- Sharkawi
//chapter 11
//example 11.6
//edition 1
//publishing place:Thomson Learning
```

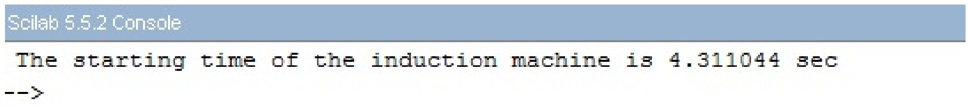


Figure 11.6: compute the starting time

```
clc;
clear;
V=480;//terminal voltage in volt
n=1120;//related full load speed of the motor in rpm
R1=1;//stator resistance in ohm
R2=1;//rotor resistance referred to stator in ohm
X1=5;//equivalent winding resistance in ohm
J=4;//inertia of the motor in NM sec^2
ns=1200;//nearest synchronous speed of the motor in
    rpm
K=1.196;
rps=ns/60;
omegas=(2*%pi*rps);
Tmax=V^(2)/(2*omegas*(R1+sqrt(R1^(2)+X1^(2))));
tau=(J*omegas)/Tmax;
smax=R2/sqrt(R1^(2)+X1^(2));
tst=(tau/K)*((0.25/smax)+(1.95*smax)+smax);
mprintf("The starting time of the motor at no load
    and full voltage and frequency is %f sec",tst)
```

Scilab code Exa 11.7 compute the starting time

```
//Book Name: Fundamentals of electrical drives by
    Mohamad A. El- Sharkawi
//chapter 11
//example 11.7
```

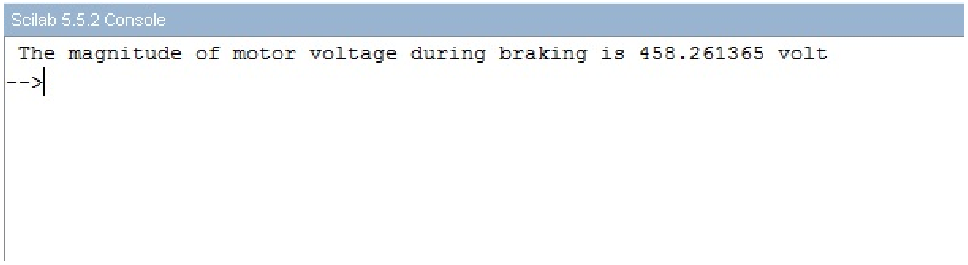


Figure 11.7: compute the magnitude of the motor voltage

```
//edition 1
//publishing place:Thomson Learning
clc;
clear;
V=480;//terminal voltage in volt
n=1120;//related full load speed of the motor in rpm
R1=1;//stator resistance in ohm
R2=1;//rotor resistance referred to stator in ohm
Radd=1;//starting resistance inserted in the rotor
    circuit in ohm
X1=5;//equivalent winding resistance in ohm
J=4;//inertia of the motor in NM sec^2
ns=1200;//nearest synchronous speed of the motor in
    rpm
rps=ns/60;
omegas=(2*%pi*rps);
smax=(R2+Radd)/sqrt(R1^(2)+X1^(2));
K=1.392;
Tmax=V^(2)/(2*omegas*(R1+sqrt(R1^(2)+X1^(2))));
tau=(J*omegas)/Tmax;
tst=(tau/K)*((0.25/smax)+(1.95*smax)+smax);
mprintf("The starting time of the induction machine
    is %f sec",tst)
```

Scilab code Exa 11.8 compute the magnitude of the motor voltage

```
//Book Name: Fundamentals of electrical drives by Mohamad A. El- Sharkawi
//chapter 11
//example 11.8
//edition 1
//publishing place:Thomson Learning
clc;
clear;
V=480;//terminal voltage in volt
n=1120;//related full load speed of the motor in rpm
R1=1;//stator resistance in ohm
R2=1;//rotor resistance referred to stator in ohm
X1=5;//equivalent winding resistance in ohm
J=4;//inertia of the motor in NM sec^2
ns=1200;//nearest synchronous speed of the motor in rpm
tbr=15;//time taken to stop the motor in sec
s1=2;
s2=1;
rps=ns/60;
omegas=(2*%pi*rps);
smax=R2/sqrt(R1^(2)+X1^(2));
Tmax=V^(2)/(2*omegas*(R1+sqrt(R1^(2)+X1^(2))));
tau=(2*tbr)/(((s1^(2)-s2^(2))/(2*smax))+(smax*log(s1/s2))+(2*smax*(s1-s2)));
Tmax1=(J*omegas)/tau;
Vbr=sqrt(Tmax1/Tmax)*V;
mprintf("The magnitude of motor voltage during braking is %f volt",Vbr)
//The answer provided in the textbook is wrong
```

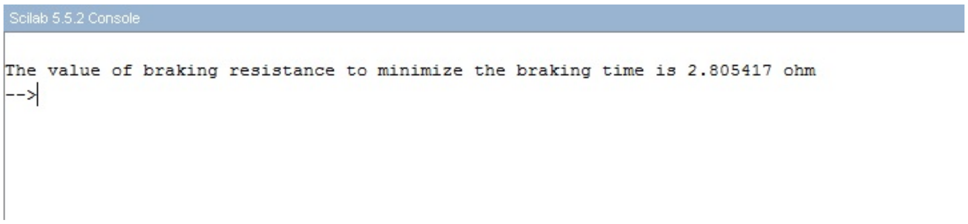


Figure 11.8: compute the value of braking resistance

Scilab code Exa 11.9 `compute the value of braking resistance`

```
//Book Name: Fundamentals of electrical drives by Mohamad A. El- Sharkawi
//chapter 11
//example 11.9
//edition 1
//publisher and place:Nelson Engineering
clc;
clear;
V=480;//terminal voltage in volt
n=1120;//related full load speed of the motor in rpm
R1=1;//stator resistance in ohm
R2=1;//rotor resistance referred to stator in ohm
Xeq=5;//equivalent winding resistance in ohm
J=4;//inertia of the motor in NM sec^2
ns=1200;//nearest synchronous speed of the motor in rpm
K=1.196;
rps=ns/60;
omegas=(2*%pi*rps);
s1=2;
s2=1;
Tmax=V^(2)/(2*omegas*(R1+sqrt(R1^(2)+Xeq^(2))));
tau=(J*omegas)/Tmax;
smax=sqrt((s2^2-s1^2)/(((-log(s1/s2))-(2*(s1-s2)))*2));//the equation is obtained by differentiating tbr with respect to smax
Radd=(smax*sqrt(R1^2+Xeq^2))-R2;//equation to find
```

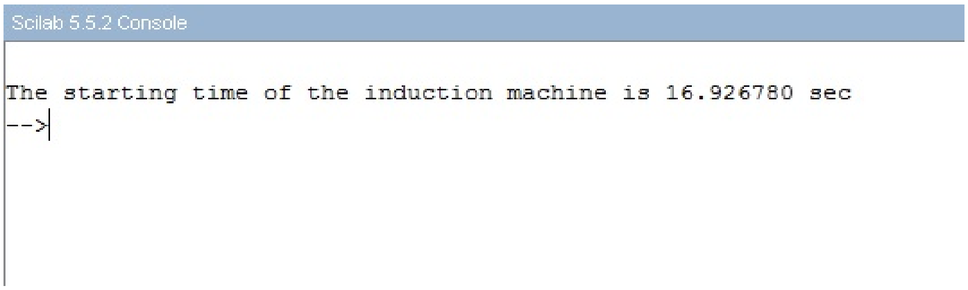


Figure 11.9: compute the starting time

```
the Radd
mprintf("\nThe value of braking resistance to minimize the braking time is %f ohm",Radd)
```

Scilab code Exa 11.10 `compute the starting time`

```
//Book Name: Fundamentals of electrical drives by Mohamad A. El- Sharkawi
//chapter 11
//example 11.10
//edition 1
//publisher and place:Nelson Engineering
clc;
clear;
V=480;//terminal voltage in volt
n=1120;//related full load speed of the motor in rpm
R1=1;//stator resistance in ohm
R2=1;//rotor resistance referred to stator in ohm
X1=5;//equivalent winding resistance in ohm
J=4;//inertia of the motor in NM sec^2
ns=1200;//nearest synchronous speed of the motor in rpm
K=1.196;
```

```
Tl=60;//load torque in Nm
rps=ns/60;
omegas=(2*%pi*rps);
Tmax1=V^(2)/(2*omegas*(R1+sqrt(R1^(2)+X1^(2))));
Tmax=fix(Tmax1)
tau=(J*omegas)/Tmax;
smax=R2/sqrt(R1^(2)+X1^(2));
TR=Tl/Tmax;
A=2*(smax^(2)-((K*smax)/TR));
Q=A^(2)-(4*smax^(2));
B=1+A+smax^(2);
mB=abs(B);
D1=(-2/sqrt(Q))*(atanh(abs(2+A)/sqrt(Q)));
D=abs(D1);
tst=(tau/TR)*(1-(((0.5*A)-smax^(2))*(abs(A*D)+log10(
    mB))));
mprintf("\nThe starting time of the induction
    machine is %f sec",tst)
```